SEVENTH

WORLD'S POULTRY CONGRESS

AND EXPOSITION

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CLEVELAND, OHIO

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The number of printed copies of the Proceedings of the Seventh World's Poultry Congress and Exposition was limited primarily to those who held full and associate membership in the Congress organization.

Inquiries concerning additional copies of this volume may be addressed to Mr. Berley Winton, Chairman, Scientific Program Committee, United States Department of Agriculture, Washington, D. C., U. S. A.

Les exemplaires imprimés des Délibérations du Septième Congrès Mondial et de l'Exposition d'Aviculture étaient tout d'abord destinés aux personnes ayant qualité de membre actif ou de membre associé de l'Organisation du Congrès.

Toutefois, des demandes d'exemplaires supplémentaires de ce volume peuvent être adressées à Mr. Berley Winton, Chairman, Scientific Program Committee, United States Department of Agriculture, Washington, D. C., U. S. A.

Die Zahl der gedruckten Exemplare der Sitzungsberichte des Siebenten Welt-Geflügelkongresses und Ausstellung war besonders auf volle und associierte Mitglieder der Kongress-Organisation beschränkt.

Anfragen bezüglich weiterer Exemplare dieses Bandes sind zu richten an Mr. Berley Winton, Chairman, Scientific Program Committee, United States Department of Agriculture, Washington, D. C., U. S. A.

El número de ejemplares impresos de los Trabajos del Séptimo Congreso Mundial y Exposición de Avicultura estaba destinado principalmente a los miembros y miembros asociados del Congreso.

Las personas que deseen ejemplares adicionales de este volumen deben dirigirse a Mr. Berley Winton, Chairman, Scientific Program Committee, United States Department of Agriculture, Washington, D. C., U. S. A.

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These Proceedings of the Seventh World's Poultry Congress and Exposition contain the addresses delivered at the General Assembly and the technical papers given in the various scientific sessions of the Congress. The papers are printed in the official language (English, French, German, or Spanish) in which each was given together with an English summary for those papers printed in a language other than English.

The World's Poultry Congresses are held under the auspices of the World's Poultry Science Association, an organization embracing poultry research, teaching, and extension work in the leading nations of the world.

Previous congresses have been held as follows:

1921, Holland; 1924, Spain; 1927, Canada;
1930, England; 1933, Italy; 1936, Germany.

In many respects the papers given in these Proceedings of the Seventh World's Poultry Congress and Exposition, held in the United States in 1939, bring up to date the results of research and other efforts on behalf of the poultry industry of the world.

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THE CONTRIBUTION OF THE POULTRY INDUSTRY TO WORLD-WIDE ABUNDANCE

By HENRY A. WALLACE, *Secretary, United States Department of Agriculture, Washington, D. C., U. S. A.*

It gives me particular pleasure to attend this international scientific gathering. In science there are no monopolies, no tariffs, and no embargoes. There is nothing to remind us of international strife and much to encourage us in the hope that eventually the human race will learn to work together in peace.

Science prospers best through an exchange of findings, in an atmosphere of freedom, and in a spirit of world-wide good will. World civilization today can for the first time produce abundantly for all needs. This potential abundance is the fruit of science. It could become actual abundance if the cooperative principle that is found in science came to guide all dealings among men—domestically and internationally. The spirit and the method of science, its practical internationalism point the way to improvement in the economic, political, and social life of the world.

In opening the Seventh World's Poultry Congress and Exposition and in welcoming the delegates, I rejoice in the knowledge that this scientific gathering will undoubtedly make an important contribution to the wealth and friendliness of nations.

This gathering is an illustration of the fact that people everywhere have similar natures, feelings, and problems. It is an illustration of the world-wide community of human interest. Men of science think of the problems with which they deal unhampered by prejudice of race or creed. Thus they foster an international democracy in searching for truth and reporting their findings. They value scientific work, not in terms of its local or national origin, but in terms of its truth and practical application.

In international gatherings like this, the natural tendency of the scientist to cooperate with his fellows throughout the world is reinforced by personal contact. And the happy influence of these contacts is not limited to the conference room; it spreads widely outside, here and at all points to which the delegates return.

This conference, of course, represents applied science as well as research. It brings together men skilled in the application as well as the theory of breeding, feeding, and disease control in the poultry industry. Practical application of the knowledge resulting from research is becoming as international as research itself. Poultry technology like poultry science progresses through pooling the methods worked out by many efforts. Each man working in the field draws more from the pool of experience than he is able to put into it. In this Congress, research, applied science, and discussion of economic problems all will promote the general welfare through an open exchange of facts and experience.

Personally I attribute great value to international commodity conferences. Important benefits have resulted from the international conferences that have been held to consider the problems of wheat, sugar, and other commodities. They have not always accomplished all they sought but their achievements have been important. Even when such a conference fails to win its objective and splits on the rocks of divergent interests it cannot fail to bring about some increase in mutual understanding.

This conference on poultry problems does not have to face stubborn international economic problems such as beset the wheat and sugar and cotton industries. Here and in other parts of the world there is increasing domestic need for poultry products. But there are important problems of consumption and marketing to solve and this international conference should provide important help.

This conference appropriately stresses production science. Occasional market gluts of poultry products are not necessarily proof that these products have been produced excessively. They do show the need for effectively moving production into consumption. We can promote this by action along two lines: (1) By stabilizing production and marketing; and (2) by increasing national income, and especially the share of the low-income groups.

I am glad to see that those who have planned and organized this Congress have arranged for the study both of production science and of distribution science. The men in charge have provided for a short course specially for farmers, commercial producers, breeders, hatcherymen, and marketing men. Leaders in poultry breeding, production, and distribution will give the lectures. Your program provides for discussion of uniform grading and consumer education, and of methods of stimulating the consumption of poultry products, such as distribution through relief channels, surplus diversion, and the new food-stamp plan. This Congress will approach all aspects of all problems of the industry.

In the United States, and in many other countries, the poultry industry is more vigorous and profitable than some other branches of agriculture. It has two great advantages. First, it tends to benefit automatically from the fact that each year there are more mouths to be fed in both Europe and America; second, it profits from the enormous recent progress in the technology of breeding, hatching, feeding, and flock management. Recent years have seen an amazing development of efficiency in the poultry industry. This has its foundation in the development of artificial incubation and brooding, in methods of raising birds in close confinement, in artificial lighting, control of temperature and ventilation, and in the use of vitamin, mineral, and protein supplements in the poultry diet. These developments have revolutionized poultry practice.

With markets expanding, and the cost of producing eggs declining the recent vigorous development of the poultry industry was but natural. The domestic markets for poultry may expand more slowly in the future, as the rate of growth in national population goes down. But another factor may offset the decline in the rate of population growth. Most countries today are concerned about the welfare of the low-income groups. In proportion as the nations succeed in improving the purchasing power of these groups the consumption of eggs and poultry per capita will rise. Efforts along this line will undoubtedly continue everywhere. The reason is plain. Technology stimulates production in all lines. Ultimately, the only way to make consumption keep step with production is to increase the consumption of the lower-income groups. No other general solution of the problem is conceivable. Here and there single nations may find outlets for their excess production in exports. But the poultrymen of most nations will have to depend largely on domestic balance between consumption and production for enlarging the market. We might as well begin along the right line now and figure on the absolute necessity of raising the consumption of the low-income groups. Poultrymen especially stand to gain.

In its rise from a small farm side line to a great commercial industry, poultry raising in the United States got off to a late start. Early in the nineteenth century poultry markets had not been developed. In the flush seasons, the farmers had poultry for sale, but mostly they raised poultry to supply eggs and meat for their own tables. City people too raised poultry for their own use just as they grew flowers and vegetables. The egg market developed before the poultry market. Eggs could be stored and transported better than fowls. Also, in a land of abundant meat, eggs were more highly prized than poultry. Now that the poultry industry has come of age commercially, with commercial hatcheries and farm flocks at once competing and collaborating, its further progress will depend largely on increased consumption. There is a margin for expansion, too, in our continued though lessened population growth, but that cannot be counted on for much more than 10 to 15 years, in the United States, at least.

In drawing a picture of the general pattern on which the poultry industry has been developing in the United States, I should like to glance back at some anniversary dates. Then I wish briefly to sketch the present position of our poultry industry in terms of income and relative prices. This will lead me to some remarks on technological development and on some of its implications.

Conditions in the American poultry industry are different in many respects from some conditions abroad; but there are points of resemblance too; and the similarities will increase with the world-wide spread of poultry science and technology. What I shall say, therefore, about our situation in the United States will be of interest to the delegates from other countries.

Every technical development we have here and many of the related economic problems have their counterpart in, or have originated in, other countries.

First, as to some of the interesting anniversary dates I mentioned, it appears that this country's first poultry show was held in Boston, Mass., in 1849. Nearly 70 years ago appeared the first poultry magazine, the Poultry Bulletin of New York City. In 1879 L. C. Byce of California is said to have made the first successful mechanical incubator that was sold to poultrymen on a commercial scale. In the same year a woman writing in the "Cultivator and Country Gentleman" described physical changes that she had observed in her fowls as autumn approached. This was the first reference to factors subsequently used in culling laying flocks. Also in 1879 Pasteur reported regarding vaccination against chicken cholera. In 1889 Rice and McGowan built but did not patent a successful trap-nest, the invention that made modern poultry breeding methods possible.

Also in 1889 Waldorf published the first report in this country on the use of artificial light to increase winter egg production. In 1899 or thereabouts the 30-dozen egg case commonly replaced the barrel. An important event in 1899 was Retgers' isolation of the germ of pullorum disease. In 1909 baby chicks began to be advertised extensively. In 1919 South Dakota passed the first good egg law; it required the candling of eggs and forbade the sale of inedible eggs. In 1929 the New Jersey Experiment Station began the first experimental work with a sectional brooder. Reinforcing all these developments was the utilization of vitamin D, the nutritional basis of the modern poultry flock with its artificial environment.

Twenty years ago it was difficult if not impossible to raise chickens in strict confinement. There was no substitute then for sunlight and access to soil. Vitamin D was still an unknown component of the fat-soluble vitamin. Scientists had not yet dreamed of vitamin G, vitamin K, and the chick antidermatosis factor. They did not know that manganese is essential in the diet of a chicken. Then came developments that revealed more about the quantitative nutritive requirements of poultry than we knew about those of all other classes of livestock together. The effects were revolutionary.

Poultrymen learned that if chickens received cod-liver oil in their diet they could be raised in confinement. Thereafter egg production was no longer uncontrollably seasonal. Scientific poultry feeding in commercial and farm flocks gave us more eggs in the fall and winter and moderated the seasonal swing of egg prices. Year-round production of broilers developed. With cod-liver oil and other fish oils in the diet, broilers could be produced every month of the year. Perosis, also known as slipped tendons or hock disease, ceased to be a bad hazard in the production of broilers. Nutrition studies showed that if the diet contained enough manganese, perosis was not likely to occur.

Many problems remain to challenge the investigator. High mortality among poultry is an outstanding one; it seems to be largely of environmental origin, and may yield to further nutrition knowledge, combined with genetic and pathological research. There are unsolved nutritional problems of gizzard erosion, "crazy chick" disease, chick dermatosis, and cannibalism. Nutrition science may show how to improve the quality of poultry meat and eggs. Eventually, it will round out the whole technique, and tell us infinitely more than we know today about the nutrition requirements of poultry for reproduction, growth, egg production, and fattening. Recent progress with egg hatchability is a sign. Not many years ago only about 60 to 70 percent of the fertile eggs set in commercial hatcheries produced live chicks. Hatcherymen can now get fertile eggs with a hatchability of 90 percent or more.

Poultry research, like other types of scientific work, knows no frontiers between countries. The benefits extend to all nations and to all human interests. Recent applications of poultry work in medicine are a reminder. Poultry investigations contributed much to revealing the facts about the vitamin B-G complex and this in turn led to a knowledge of the role of nicotinic acid in the prevention of pellagra. Nutrition studies with chicks and rats showed that there is more than one kind of vitamin D and that the several kinds are not equally effective in all species. This discovery had a direct application to human nutrition. Experiments with chicks revealed the antihemorrhagic factor, or vitamin K. This vitamin quickly proved of value in pre-operative treatment for the prevention of post-operative hemorrhage in surgical operations on the gall bladder and bile ducts. These facts are new evidence of the familiar truth that the byproducts of research are often as important as the intended results.

In connection with the nutrition of poultry we should notice the place of poultry products in human nutrition. Poultry, like other meats, is valuable for its protein, since protein of good quality is an essential body-building material. It is a good source of phosphorus and iron. Poultry also contains riboflavin (vitamin G) and thiamin (vitamin B_1), and nicotinic acid (the pellagra-preventing factor). Eggs contain many of the substances essential for human growth and development. They furnish protein, calcium, phosphorus, and iron, as well as vitamins. The yolk is an excellent source of vitamin A; it is an excellent or a good source of vitamin D. In this vitamin its value depends on the diet of the hen. Eggs from flocks that get vitamin-rich diets are especially rich in vitamins A and B. Eggs also are a good source of riboflavin (vitamin G), thiamin (vitamin B_1), and a fair source of nicotinic acid. Because they contribute minerals, vitamins, and proteins, eggs are a good food for human beings of all ages.

Let us turn now to the reflection of these developments in poultry prices and incomes. Fifty years ago prices in this country were very low for all poultry products. Taking the period 1910–14 as 100 we find that the purchasing power of chickens in exchange for other farm products was only 80 in 1879. In recent years it has been around 120. In the 50-year period the purchasing power of chickens in comparison with other farm products has risen 50 percent. Eggs have not risen so greatly in purchasing power. Eggs at wholesale in New York in 1938 were only 14 percent higher than in 1888, while dressed fowl at wholesale were 64 percent higher in 1938 than in 1888. This disparity results partly, of course, from the fact that a modern hen produces more eggs. There are other reasons too. Fifty years ago, for example, the market fowl was much inferior to the modern product.

Chickens and eggs are making an increasingly important contribution to farm income. In fact, in 1938 poultry and eggs produced more gross income in the United States than any other one farm commodity except milk, cattle, and hogs. Poultry and eggs produced nearly $1,000,000,000, or about 12 percent of the total farm income. This is surprising in view of the fact that poultry is still largely a farm side line. Fifty years ago the gross farm income from poultry and eggs was only about 5 percent of the total. We may contrast this showing with that of wheat. Fifty years ago wheat provided about 12 percent of the gross farm income. Now it returns only about 5 or 6 percent.

The rising place of poultry in the farm economy reflects once more the difference between producing for the domestic and producing for the foreign market. Crops that we produce heavily for export, with the exception of tobacco, are in a much worse relative price position than the crops produced mainly for consumption in this country.

Fifty years ago our poultry produced about nine dozen eggs annually for every man, woman, and child in the United States. Today it produces about 22 dozen eggs annually per capita. Commercial production in specialized breeds is becoming more and more important. Egg production from this source will undoubtedly become a still larger proportion of the total output. Our commercial hatcheries in 1934 had an estimated total capacity of 276,000,000 chicks, and their capacity is considerably larger now. Sample flock returns indicate that commercial flocks produce about 19 percent more eggs per layer than average farm flocks. Farm flocks, however, have begun to improve in recent years. In 1938 the average production per layer in farm flocks was 106 eggs as compared with only 90 in 1925.

Nowadays the progress of technology spreads to more producers more rapidly than it did formerly. In the poultry industry it benefits the small flock-owner, as well as the large producers with large capital. Through the purchase of well-bred baby chicks the small-flock owner can improve his flock quickly and uniformly. He can buy or build efficient poultry houses at low cost. He can provide a balanced ration for his birds, combined scientifically from the products of his own farm, or developed from such products with the addition of purchased vitamin concentrates. Improved marketing, perhaps in cooperation with his neighbors, can bring to him the advantages of low-cost, judicious distribution. He can fit his poultry operations skillfully into the rest of his farm work, in such a way as to diversify his sources of income, utilize time and labor that might otherwise go to waste, and add something to the fertility of his land.

These advantages, along with the smaller overhead costs that usually distinguish poultry raising on the farm from poultry raising in large commercial plants on expensive land near large cities, are at least a partial offset to the efficiency of large-scale, highly mechanized and highly commercial production. Moreover, the opportunity to supply nearby local markets, as well as to improve the farm table, gives the farm flock a place in the poultry economy from which it will not easily be dislodged. There is an excellent prospect that farm flocks and specialized commercial poultry enterprises will become more and more complementary rather than more and more competitive, and that scientific principles and methods will gradually permeate the entire industry.

Here and in other countries the poultry industry has complex economic problems. These problems differ more from one country to another than do the technological problems; they arise from an immense variety of social conditions. Standards of living vary widely. Some countries produce poultry and eggs for export. Other countries do not satisfy their own requirements. Still other countries simultaneously import and export poultry products in large quantities. Nearly all countries have one task in common; they must raise the living standards of the poor. As I have said, this is the true path toward a balanced economy, and the path also toward increased consumption of poultry and eggs.

One of the serious problems of the poultry industry in this country has been the lack of stability in prices and supplies of feeds and the lack of stability in prices and supplies of poultry and eggs. Excessively large feed supplies at excessively low prices encouraged new producers to go into the business and encouraged old producers to increase their business. The great droughts of 1934 and 1936 resulted in short feed supplies and rapidly rising feed prices. Prices for poultry and eggs did not keep pace with the prices for feed.

Poultrymen would like to be able to plan ahead both on the basis of prices they can expect to receive for their products and on costs of producing them. If they have no assurance of stability in feed supplies and prices and no assurance of stability in production of poultry and eggs the hazards of the business are extreme.

Here in the United States we are trying to stabilize feed supplies and prices through the national farm program. The Ever Normal Granary which is a basic part of this program is maintained through provisions for storing the surpluses of years of good weather for use in years of bad crop weather. Our experience as yet has been limited. But we do know that we are less likely to suffer from feed crop shortage. We know that the commodity loans and the storage of grain surpluses have stabilized prices and evened out marketings. Adjustment of feed-grain acreage, along with prudent storage against years of drought, will lessen the speculative hazard in the poultry industry. Future World's Poultry Congresses may record as much progress toward the solution of this problem and the problem of translating the abundant poultry production that science makes possible into abundance of these healthful foods in the diets of all as the present Congress records toward the solution of problems in poultry breeding, feeding, and care.

It is indeed a great pleasure to have appeared before these representatives from 21 nations. As a result of our meeting here together during the ensuing week I am sure the world will be a better place to live in. I hope you will enjoy yourselves and that you will carry much instruction home to your native lands from these marvelous exhibits and instructive scientific papers.

POULTRY NUTRITION AND ITS CONTRIBUTION TO THE DEVELOPMENT OF THE WORLD'S POULTRY INDUSTRY

By PROF. DR. ERNST MANGOLD, *Institute for Animal Nutrition, University of Berlin, Berlin, Germany*

The subject which I have the honor to discuss in this general assembly is a part of the general question: Which are the factors that have contributed to the enormous development of the world's poultry industry in the last 40 years? And in discussing this subject, it is not so much to express our satisfaction for the successes we have attained up to the present time, as to gain a position from which we may look back into the past and, by learning from our experiences, to begin a new continuous development for the future.

Poultry husbandry began in a very primitive and purely empirical way, the only method of advancement being that of "trial and error," as the famous American physiologist Jennings has called it in the lower organisms. And the first decided progress, made by Charles Darwin, who was working with pigeons on heredity, had its origin in the redetection of the Mendelian laws of inheritance at the beginning of our century.

Until that time, as Francis has pointed out, poultry keeping was only a despised adjunct to farming practice, and the farmer was convinced that poultry keeping was not profitable except for his wife. It was the Cinderella of stock farming (Moskovits), and poultry were regarded merely as scavengers or as a means of using inferior grains produced on the farm (Halnan). Only the increasing demand for eggs and table poultry and the greater importation of those products caused more attention to be paid to the possibilities of a poultry industry and gave rise to its enormous expansion in the following years.

But this progress would not have been possible with the old traditional methods and with only empirical knowledge of the production of eggs and chickens. And so, beginning in those countries where poultry husbandry first expanded into larger industrial forms, we observe a very remarkable approach of practical poultry keeping to the biological sciences. This relation has developed in two ways: First, the application of scientific knowledge in general biology to the problems of poultry husbandry; and second, the beginning of a poultry science based on the principles of biology and economics.

On the biological side the most important sciences were those of genetics, physiology of nutrition, and, in the medical line, pathology and parasitology. It is my task to discuss poultry nutrition and the influence of the science of nutrition on poultry practice in the improvement of the poultry industry.

It is impossible to accomplish this in exact figures and to draw an historical parallel numerically between the science of nutrition and the world's poultry industry. For, as Brizi has pointed out at the World's Poultry Congress at Rome, in many countries there are no precise statistics on the poultry industry, and in general there were none until the Great War.

So we cannot get an exact comparison from year to year, as we can in other cases, e.g., on the influence of the nutrition of babies on their mortality. But we can sketch the general lines on which nutrition and its scientific investigation have contributed to the development of the poultry industry.

The first motive to induce the application of the science of nutrition in this practical field must have been the perception that the quantity and quality of feeds are the most important factors in producing a greater quantity and better quality of poultry products, by keeping the birds healthy, augmenting the egg-laying capacity, accelerating the growth of chickens, shortening the time required to reach maturity, and increasing the weight during fattening, and because of all this, increasing the profits of the farmer or poultry keeper.

A further stimulus was the appearance and development of the industrial feeds, which present additional possibilities to the production of feeds on the farms, but at the same time make necessary a better and more extensive knowledge of feeds, of their chemical composition, and of the physiological significance of each nutrient for the metabolism and energetics of the animal body. It appears that the prophetic words of Wingfield and Johnson in their poultry book of 1853 have been realized:

> Some knowledge of the various properties of the different articles of food becomes essential, wherever the best return is to be obtained at the least outlay. A precise chemical analysis of such effects, verified by experiments, is what we hope we may soon possess.

This was written at a time when the authors, on reviewing several hundred volumes of agricultural surveys, could find nothing about poultry keeping other than the laconic confession: The profits arising from poultry are too inconsiderable to enter into the calculation of the farmer; and when poultry fattening in England was effectuated on the simple precept—Feed them on rice porridge made with milk; it fattens and makes them white.

It was in the same year of 1853 that Dickson laid down as a principle the impossibility of ascertaining the best sort of feed without some knowledge of the structure and functions of the organs of digestion, in other words, of the physiology of the animal digestion and metabolism. But still 20 years later Tegetmeier complained that the scientific principles of feeding were frequently ignored and that poultry feeding was performed only on empirical opinions. This slowness of comprehension in regard to the art of poultry keeping as an applied science had its causes partly in the mutual dependence of practice and poultry science; for only an enlarging commercial poultry industry could be ready to take up the new results of the science of nutrition. The resulting improvement in production would more than oblige poultry keepers to consult science about all questions concerning the relations of feeding to a further increase in the quantity and quality of the products; and so again the science of nutrition would receive new motives for answering those questions by the performing of new experiments in respect to feeding and feed utilization.

Because practical men were forced to obtain better knowledge of scientific results from poultry researches, there developed a great body of extension work for the propagation of poultry science, including nutrition, among those persons engaged in the world's poultry industry.

I feel it undesirable to confine my discussion to an historical description of how poultry nutrition and poultry industry were developed, for it was at the World's Poultry Congresses at Rome and Leipzig that such historical information about poultry keeping in the world at large was presented by such famous representatives of the different countries as Francis, Funkqvist, Ghigi, Hannah, Huizinga, Podhradsky, Römer, and others. I think my task is a more constructive one when I give you something resembling a program concerning the relations between the science of poultry nutrition and practice as they are now working and must work in the future, for a further development of the world's poultry industry.

The most striking evidence of the indispensable basic work of the science of nutrition for practical poultry husbandry is given by those tables containing data on feeds and feeding standards for suitable rations. There is, first, the table of poultry feeds with the percentages of the various organic nutrients: Protein, fat, soluble carbohydrates, and crude fiber, according to chemical analyses. The older such a table is, the more it loses its practical usefulness, since in the older tables there are always missing some of the more modern feeds which have been developed by agriculture or prepared by industry. Even in the well-known cereals, etc., the average contents of nutrients are constantly being altered by agricultural measures of breeding and fertilizing. Still more it is to be remembered that every science is constantly changing and developing, so that the newer the chemical analyses are, the better. It is a fact worthy of consideration that due to agricultural chemistry and nutritional science, new tables of feeds containing the most recent figures of feeding values are constantly being prepared.

Secondly, there is the table of digestion coefficients, giving the percentages of digestibility of the nutrients of the various feeding materials for poultry. Here the only possibility of obtaining the correct figures are the digestion experiments with poultry. The time has passed when such tables consist chiefly of coefficients from experiments with pigs, because of a want of available data on poultry. Today, although most feeds are tested only on chickens, these same figures are used for the feed calculation for all the different kinds of poultry. Since in the more recent of our own experiments with pigeons we obtained very different digestion coefficients from those with hens, especially for the most important nutrient, protein, it seems to be necessary to do a great deal more experimental work to obtain the correct figures for each of the various species of poultry. And here it must be said that many of the earlier digestion experiments with hens were performed with methods that could not stand scientific criticism so well as the exact methods we have now.

Therefore, new tasks are always arising for the science of poultry nutrition as basic work for practical poultry feeding and feed calculation.

For the third sort of tables, giving the percentages of digestible nutrients in feeds, the figures are computed from those of the raw feeding materials and the digestion coefficients in the former tables. In fact, the farmer is supplying to his poultry the feed with all its digestible and indigestible substances, the latter forming the bulk with a physiological significance on digestion only in a purely mechanical way. But for the feed calculation for the various purposes of production, it is not sufficient to calculate only the total intake of feed with its content of water and ballast, because it is only the digestible part of the dry substance that is utilized in the metabolism of animals for their maintenance and their products. So, for instance, if in the raising of chickens the farmer wishes to compare the effect of a new feed with that of an old approved one, it may be of use to know whether the proteins of the new feed are digestible to the same degree as those of the old one. If, e.g., the protein of the new feed is that of industrial feeds, dried with high temperature, the digestibility of protein is not so high as in common cereals or in fresh skim milk. Therefore, for all cases of exact feed calculation the tables of digestible nutrients will give him the right figures.

The three sorts of tables that I have mentioned may be regarded as the most important contributions of poultry nutrition to the development of the poultry industry. For this development would have been impossible without this exact basic work and without the use of the pencil in the hand of the poultry farmer (Römer).

These tables have had a very slow development because of their dependence on the progress of chemical methods and of physiological experiments. The first table of poultry feeds, it seems, was that of Tegetmeier in 1855, giving the percentages of fat, crude fiber, flesh-forming substance—as he called protein—and heat-producing substance—by which he meant carbohydrates. In this table, however, were tabulated only 10 different feeds. The first digestion coefficients for poultry were published by Völtz after experiments with preternatural anus in 1909. Soon the well-known tables of Kellner were applied to the calculation of poultry feed and used in the numerous editions of the poultry book of Dürigen and others. But it was not until 1925 that Lehmann began to publish his tables of digestible nutrients of feeds corrected every year according to the new analyses and trials in the Pfenningstorff calendar for poultry keepers. In America, it seems, it was Fraps who gave the analogous, but independent tables, in 1928.

There are still other sorts of tables on poultry nutrition, the origins of which are as old as those tables mentioned earlier. It was the valuation of feeds that had been recognized as very important for poultry husbandry. As it seems, Wingfield and Johnson were the first authors, who in 1853 published tables of a larger extent about feed intake and costs according to feeding experiments on poultry. At that time and for a long time afterward, it was only because of the desire of commercial interests for a more economical production of poultry that such feeding experiments were performed, by comparing the total intake of feed and the average daily labor and costs of keeping the birds with the amount of production either in the number and weight of eggs or in growth of chickens. In recent times a great contribution of the science of nutrition to practical poultry feeding has been made, since it has shown that for the valuation of the feeds the amount of total feed intake had to be shown in terms of the individual feedstuffs, according to their percentage of crude and digestible feeding ingredients and to the protein relation, in order to obtain the total amount of the organic nutrients and especially of the protein needed for every 100 grams of egg substance or of gain in weight as units of production. This is the method of the feed-valuation figures developed by Lehmann by means of nutrition experiments with various species of poultry, and by which he has shown that fattening is thus more economical with young animals than with older ones.

The calculation of feeding values may be done also in the reciprocal way, which is preferred by American poultry scientists, the average gain per gram of feed and of protein consumed being obtained.

In general, we may adopt the method of Krizenecky for distinguishing between the physiological and economic values of feeds for poultry. We know now that this latter method is based on the exact performance of physiological feeding trials as the only means of acquiring reliable figures on the cost of producing a pound of gain or of eggs in poultry.

As to the previously mentioned protein relation, it is a well-known contribution of experimental work that for every sort of production at its optimum the ratio of protein to nonprotein nutrients has a precise value. We know now that these standard figures of the protein relation or of the percentage of protein in the feed may not be applied dogmatically. For great differences exist among the proteins of various origins with respect to their so-called biological value. Every protein is constituted from a combination of some 27 different amino acids as the building stones of the protein molecule. Now the utilization of the digestible part of the protein for the maintenance of metabolism of animals as well as for their production, as shown by K. Thomas, is dependent on the right combination in number and sort of amino acids. Therefore, to obtain a high standard of production in the poultry industry we cannot afford to dispense with some protein of animal origin, because this is of greater biological value than all proteins of plants. And it is a very real task now for the science of nutrition to determine the biological value of the protein of all feeds for the purpose of giving these formulas for the correct feed combinations for all kinds of agricultural animals and all sorts of their productions.

As to poultry, this contribution of scientific research to practical feeding is only in its beginning, so that we may await further successes in this line.

We may make the same prognosis in regard to our knowledge of the mineral supply in poultry feeds. This is a very difficult field, since every mineral has its own significance for the physiological functions of the body, and at the same time the quantitative relations between the various minerals are extremely important in the metabolism of the growing or high-producing animal. Therefore, experimental science has still to do a great deal of research concerning the mineral supply for giving the fundamentals for practical feeding. Even more urgent than our work along these lines is our fight to overcome some superstitions, such as Holst, Newlon, and Halnan have already discredited about common salt, which was believed to be poisonous for poultry. These researchers found that salt is injurious only in concentrated form, and for human beings as well, but in carefully regulated doses is to be recommended for regular addition to poultry feeds.

The mineral supply is a very modern question of nutrition, not only in consequence of the recent development of our physiological knowledge of mineral metabolism, but also because of new experiences in the pathological field; for in recent times every year brings forth a series of new cases of diseases in animals that are believed to be caused by deficiency of some minerals or by too much of others. I must restrict myself here to mentioning these very important connections and to citing, as an example, the researches of K. W. Franke of South Dakota on selenium poisoning of cattle and on the toxic effect of alkalied grain for chickens.

But the close relationships of nutrition and disease are by no means limited to the mineral substances; for it is well known that all our knowledge of the vitamins was inaugurated by the famous discovery of Eijkman that the beriberi or polyneuritis of fowl and pigeons is caused by the unbalanced feeding of polished rice. You know that in America Hess and Weinstock and Hart and Steenbock carried out their fundamental researches on light and ultraviolet irradiation of animals or of their feed as an antirachitic factor in poultry, and that in connection with these detections Windaus in Göttingen showed ergosterin to be the provitamin of vitamin D.

It is hardly possible to exaggerate the importance and the practical consequences of such scientific discoveries in the field of nutrition. We must acknowledge with gratitude that especially the experimental work done on the preventive or curative effect of vitamins on poultry has given to all fields of the poultry industry, and especially to intensive poultry keeping, such a development and success in production as could never be hoped to be attained in former times.

It is obvious that the influence, on the development of the poultry industry, of all the single fields of the science of nutrition, which we can discuss here in only a very brief manner, could not have been so successful without the simultaneous successful evolution of the other sciences supplying poultry keeping with basic scientific work; for the feed, as Filler has pointed out, is only one part of the so-called environmental surrounding conditions that may influence the health and productivity of poultry. As the researches of P. Hertwig in genetics have shown, the ability of the hen to convert feed into egg substance is bound to inherited faculties. Therefore, it is one of the most important principles of poultry breeding, as Vetter has accentuated, to use for breeding only such animals as are able to utilize their feed intake for an optimal quantity and quality of products.

Therefore, there are many relations of poultry nutrition to breeding and genetics, and likewise to pathology and parasitology, as well as to economics, and all investigations in these fields must be united in one general poultry science as a basis for a continuous improvement of poultry practice. And, in closing, we may hope with confidence that in the future poultry nutrition, side by side with those other sciences, and in the mutual coworking of scientific research and practical experiences, will never cease to contribute to the development of the world's poultry industry.

CONTRIBUTIONS OF GENETICS TO THE WORLD'S POULTRY INDUSTRY

By PROF. R. C. PUNNETT, *Professor of Genetics, Cambridge University, Cambridge, England*

Less than 40 years ago a new science came into being—a science which, as the years went on, has become of more and more importance for our comprehension of the world of life. Genetics, as Bateson called it, owed its rise to the rediscovery of Mendel's long-forgotten work. That classic little paper of forty-odd pages proved to be the starting point of the vast series of researches by hundreds of workers in every civilized land which has so profoundly altered our ideas of the living thing. Heredity before Mendel was an article of faith embodied in such vague phrases as "like begets like" and "blood tells." Today heredity is an exact science ranking with physics and chemistry in precision of method and clarity of conception. And so far as I can understand the implications of physical science, I think we are entitled to say that at present we know as much of the gene as we do of the atom or the electron. That the conquest of the latter should have excited so much more interest is due largely to the size of the canvas on which it has been splashed. The one colors the finite universe; the other, only a thin scum of protoplasm unevenly spread upon the little planet earth. Of these two great conquests wrought by the human mind, our concern today is with the glory of the terrestrial. Mundane things claim us, for we are of the earth—earthy. Genetics is what we have before us, and our present business is to appraise its value in the service of the ideals which this congress has set up. What has the science of genetics done for the poultry industry, what is it doing, and what could it do?

In the first place, what has it done? It is more than 35 years since I joined Bateson in his work. He had already begun to breed hens, and I have been breeding hens ever since. Looking back over that period I confess to some feeling of disappointment. In those early years things seemed to be moving very fast. Comb characters, down characters, plumage color and pattern, shank color, skin color—all these things were submitted to our analysis, and all ultimately yielded to it. It must be remembered that at that time we were breeding fowls merely because they offered convenient material for unravelling the problems of heredity. We might equally well have been using rats or grasshoppers. Nevertheless, small points of interest to the practical breeder were definitely elucidated. We were able to tell him how to rid himself of unwanted recessive characters that threw suspicion on the purity of his strain. We could tell the breeder of Wyandottes how to get rid of those single combs or of the occasional colored birds that cropped up among his whites. We could tell the breeder of Sussex how to get rid of those troublesome yellow legs; and there were many other such minor problems in which we could have helped. No one, of course, asked us, and it was not for scientific cranks like ourselves to teach expert breeders their business. When we met them they were always very kind to us, freely discussing various points, though I think many of them would have been surprised at the conclusions we drew from what they had told us. But friendly as relations were, we were completely out of touch, and we realized that until the breeder had mastered the elements of Mendelism, viewing his birds as we viewed them, we could be of little help even if we desired it. Meanwhile we were very busy with our experiments, and before Bateson moved from Cambridge in 1909 the principle of sex-linkage had been discovered, though a decade was to pass before there was any suggestion of its practical application.

So far, we had been working with simple visible characters, external structure, color, and the like, and we had satisfied ourselves that their heredity fitted in with the Mendelian scheme. At that time there were critics who suggested that, although some characters might exhibit simple alternative inheritance, there were others which were not amenable to such a scheme. Such, they claimed, were characters of the "more or less" variety, showing an apparently continuous grading from one extreme to the other. They considered this so-called "blending inheritance" to be essentially different from the clear-cut Mendelian type. Consequently when, in 1910, I began afresh by myself, I decided to test the matter experimentally, choosing as materials for investigation egg color and size of bird. As most of you know, if one crosses a heavy breed with a light one, the resulting birds are intermediate in size; and if one breeds these together there is nothing resembling typical Mendelian segregation in the next generation, but one obtains a series of birds ranging from light to heavy in an apparently continuous series—in fact, typical so-called blending inheritance. In the case of a cross between brown and white egg breeds also one comes across a similar phenomenon. In these rather laborious experiments I was helped by the late P. G. Bailey, and we proved, to our own satisfaction at any rate, that these typical cases of blending inheritance could be simply interpreted on the Mendelian scheme in terms of several, though few, Mendelian factors. These experiments served to confirm the conclusion at which we had already arrived, viz, that there was only one kind of heredity which was dependent on the transmission of definite factors, or, as they are now called, genes. Blending inheritance was merely a special case in which a measurable character depended, for its expression, on a number of genes, any of which might or might not be present.

I need hardly say that this conclusion was not reached through work on poultry alone. A large body of facts, drawn mainly from experiments with plants, already pointed the same way. Nevertheless, I think the hen is entitled to some credit since, with the exception of Arnold Lang's interpretation of ear length in rabbits, she provided the earliest examples reconciling blending with Mendelian heredity.

The period with which I have been dealing brings us up to the end of the Great War, and in England at any rate the geneticist and the practical breeder were quite apart, pursuing their ends with little or no thought of the other. The contact between them was first made on the American side of the Atlantic, where the vast economic importance of poultry was earlier realized, and I am inclined to think that it was Raymond Pearl's work at the Maine Agricultural Experiment Station which first led to a recognition of the geneticist on the part of the industry. Pearl attacked the problem of laying capacity, a problem of vital interest to all poultry keepers, big or small. His claim to have discovered a sex-linked gene affecting egg yield interested all, and although that claim has not been substantiated by later work on both sides of the Atlantic, to Pearl should go the credit for having made the first effective contact between the science of genetics and the industry. This contact was shortly to be cemented by an opportune happening in England. During the course of our work in Cambridge, we had paid attention to the down color of our chicks and had noticed, among other things, the differences between those that later developed silver and those that developed gold plumage, and also between those that developed black and those that developed barred plumage. In fact, we were already making use of sex-linkage in our experimental work before the war, though it never occurred to us that it might be of economic value. The suggestion came to me only when going through some correspondence at the Food Production Department toward the end of the war, and when the International Poultry Congress met in London in 1919 I tried to interest the assembled breeders in the matter. The seed so scattered fell for the most part on stony ground, but fortunately one or two breeders had faith, and the success that attended their efforts soon banished any lingering incredulity. The breeder sat up, for the geneticist had at last accomplished something worth while, something which markedly affected the outlook and welfare of the industry. Henceforward he was to be taken seriously for out of his work might at any time come something with a material bearing on the breeder's prosperity.

This I take to be the chief thing that the science of genetics has accomplished for the industry directly. Sex-linkage is of course of some practical importance, but I regard it as a minor thing in comparison with the change wrought in the breeder's outlook. Gone are the days when the scientist was looked upon as a harmless crank, when the experimental method was regarded as a futile pursuit unworthy of the serious attention of the practical man. The breeder now realizes that genetics can help him to solve his problems, and the geneticist, assured of the good will of the practical man, is more willing to learn the nature of those problems and to direct his activities into lines which may be helpful. The contact originally established by Pearl has strengthened into a permanent bond. The practical man and the scientist have got together, and this I consider the most important thing that genetics has so far accomplished for the industry.

We may now turn to the question of what genetics is doing today in furtherance of the industry's interests. And here I am at a great disadvantage, for I am unable to speak at first hand of all the work going on here in America. That the geneticist is busy, very busy, with all sorts of problems affecting the practical conduct of the industry I know very well from the numerous bulletins that reach me from your experiment stations, the largest and best equipped in the world. You are attacking the problems of fecundity, of fertility, and of mortality, both in the shell and in later life, and I feel confident that sooner or later there will emerge results commensurate with the high endeavor—results which will place in the debt of your geneticists poultry keepers all over the world. Compared with all this, we in England are doing little. The resources of our poultry geneticists are very small compared with yours, though I am glad to say there is good prospect of their becoming more adequate in the near future. Perhaps, however, I may be allowed to say a few words on what is at present the most striking line of research going on among us, because, so far as I know, it is at present peculiar to our side of the Atlantic. This is the work involved in building up what we have termed "autosexing" breeds, and it is the outcome of certain peculiarities in the action of the well known "barred" gene. Barring, as everybody knows today, is a dominant sex-linked gene, so that when a barred hen, such as a Plymouth Rock, is mated to a cock of a black breed the cockerels are all barred and the pullets are all black. And since there is a difference in the downs of barred and black chicks, the sexes can be readily separated at hatching. It is one of the commonest of sex-linked crosses, and doubtless many of those present have put it into practice. Since barring is sex-linked, it follows that in pure Plymouth Rocks the male is always homozygous and the female heterozygous for the barred gene. In pure Plymouth Rocks all chicks show the barred type of down, but it is not possible to separate with certainty the heterozygous from the homozygous ones, i.e., the females from the males. This is because the single dose of the gene in female chicks produces almost the same effect on a black down as does the double-dose characteristic for the males. With a brown, however, the effect is different. A double dose of the barred gene produces a much more marked effect than does a single dose. By associating the barred gene with a brown down we obtain a breed in which the cocks are homozygous and the hens heterozygous for the gene. And since, owing to their double dose of the barred gene, the former are always lighter in down color than the latter, we have a pure breed in which the sexes can be distinguished with certainty at hatching. The first such autosexing breed made by Mr. Pease and myself was founded on the Campine, being in fact a Campine plus the barring gene. We called it the Combar, and under this name it is a recognized breed in England. At the same time we pointed out that the method could be applied to any breed with a brown down, and more recently both Dr. Hagedoorn in Holland and we ourselves in England have introduced the barring gene into the Brown Leghorn and so produced the Legbar. Recent experiments by Mr. Pease suggest that the principle can also be applied to paler types of down, such as buff, thus opening up the possibility of producing a great range of such autosexing breeds. In this way it is possible to dispense with the Chinese method of chick sexing, a method which is not only an additional source of expense to the breeder, but also one which in unskilled hands often results in loss through damage to the fragile newly hatched chick. Such breeds also have the advantage that the hens may be used for sex-linkage by the ordinary method of crossing.

This is all I need to say about the present, for in a congress of this sort you will hear of all that is going on from other lips than mine. There lies before me now the future of genetic research in connection with poultry breeding. On this subject probably no two of us here think exactly alike. Therefore, before I inflict upon you my own ideas it may be as well to try to state the frame of mind in which I am led to approach the matter. And I do not think I can make this clearer than by quoting and emending a sentence from a seventeenth century philosopher. "All that Man knows," wrote John Locke, "or ever will know, is by Observation and Reflection." Now the life of Locke overlapped that of Harvey, founder of the experimental method in biology, and in the times in which our philosopher flourished the new method had hardly begun to bear fruit. Had Locke lived a little later we may feel sure he would have accepted the addition of the word "experiment" to his dictum. If we do so we have the creed of the geneticist in common with that of all other men of science. In so far as observation is concerned the practical breeder can greatly help. Faithful observation faithfully recorded by an unbiased mind may often be of great assistance in devising experiments to solve a problem. But the breeder must not expect to solve his problems by observation alone, however extensive. It may be that on occasion he will do so, but in such a case we can only account him very, very fortunate. Today I think that most of us agree that observation and reflection must be accompanied by experiment, and that is what I wish to stress. The experimental part of the acquisition of knowledge must be left to the trained geneticist. For the devising of a crucial experiment is not a matter to be lightly undertaken. Somebody once said that Nature will always give you a clear answer provided you put to her the right question. Therein lies the core of the matter, the decision as to what constitutes the right question. "Well begun is half done," says the old proverb, and he who formulates his question rightly has already got half way to the answer. To do this requires not only the gift of imagination but also a mind that has ranged far and wide. It is not enough for the poultry geneticist to be skilled only in the genetics of poultry. The wider his range over the whole field of genetics, plants as well as animals, the more likely he is to formulate his questions in the right way. I can never forget that, in days long since, the clue to discovery of sex-linkage came from certain experiments with sweet peas, or that the conception of multiple factors which brought blending inheritance into line with Mendelism was provided by Nilsson-Ehle's work on wheat. He who formulates our poultry problems today must have an adequate knowledge of physiology, and above all of that branch of it which concerns itself with hormones. For it is certain that these hormones are going to play a very important part in connection with our poultry problems. Fancifully we may liken them to the various oils adapted to different kinds of machinery. The delicate gene mechanism revolves smoothly with one oil, with another it clogs. One should never anoint the clock with linseed oil if one wishes to keep appointments. To what extent the production of these hormones is referable to the gene, or to what extent it is an extrinsic process, is beyond us at present to state with certainty. Their nature and manner of production in the body constitute a fascinating problem of which the solution is bound to be of very great importance to the breeder of poultry. For the production of the right kind of hormone and the right amount of it, infinitesimal though this often is, may make all the difference between a good bird and a bad one.

To return now to the future of the genetic research in connection with poultry. This I feel to fall into two categories—a higher and a lower. The former consists in the formulation of problems concerning matters where our ignorance is deep, where contradictions abound, and precision is only conspicuous by its absence. Such matters are those of vitality, of fecundity, and of fertility, as well as all such as are included under the term "stamina." Today we can express none of these things in terms of genes, yet that is what we must be able to do if we desire to control them. That is our immediate problem—to express these elusive things in terms of the gene. That it can be done I feel confident. Those who may have doubts need only turn to the story of the little fruitfly *Drosophila*. When the geneticist first turned his attention to it some 30 years ago, it offered a virgin field for research. Through the work of T. H. Morgan and his colleagues first of all, and then through that of many others, we have come to know far more of this little creature than of any other living thing. Almost infinite as are the variations of *Drosophila*, their analysis in terms of the gene has brought them under the control of the geneticist. He has shown that the genes of living things are in a sense comparable to the molecules and atoms of the chemist. Give the chemist an unknown substance and he will first analyze it to discover the manner in which its molecules are built up. And then he can proceed to synthesize it, perhaps from substances altogether different. So with the living thing. First it must be analyzed into its component genes. This gives the measure of its potentialities, and after that the process of synthesis, of arranging the genes to give the type that is wanted, is a relatively simple process. Nowhere, as I have already said, has this process of analysis proceeded so far as in *Drosophila*. But it is actively proceeding in many plants, and hosts of new and valuable varieties are already the outcome. Moreover, there is another aspect of the adequate analysis which is increasing in importance. By X-rays and other methods it has been found possible to alter the composition of the gene. Novelties result, all of interest, and some of possible value to mankind. Such work, however, to be fruitful demands the use of material of known genetic composition. But I need do no more than hint at such possibilities, since it is the hen with which we are concerned. And the genetic analysis of the hen has as yet hardly begun. It will be a long and arduous business, but unless it is undertaken and faithfully carried through you may as well eliminate genetics from these congresses in the future. Its success will depend on those whom you select to put to Nature the appropriate questions. The history of scientific research shows that such men are few. But everything depends ultimately on them. For the purpose we are discussing, one single first-rate brain is worth hundreds of second-grade ones. Very rare are those who can so put the question to Nature as to force from her a clear and unequivocal answer. Therefore I would urge those who control the finances of research to seize at all costs any that are available. The initial expense may be greater, but in the end it will be far less for what is accomplished because of their immensely greater penetrating power. Nor is it for me or anybody else to suggest their line of research. If you feel that you have the right man you must give him his head and trust him, realizing that mentally he is a born rebel. Don't bother him with committees and reports and programs of research. You want discovery, and discoveries are not obtained in that way. Discovery is a gamble, and you can no more organize it than you can organize poetry or painting. If you try to do so you will surely end by killing it.

So much then for what I have termed the higher category of research. I admit that it is beyond the great majority of us, and it is with some relief that I feel that there is plenty yet for us to do in what I have called the lower category. By this I mean the working out of the discoveries of others, of those few who have already put successful questions to Nature. Though not a great deal, we do know something of the genetics of the hen, and there is much yet to be learned along straightforward orthodox lines. There are plenty of characters, simple visible ones, such as color and pattern of plumage, which have yet to be analyzed and translated into terms of the gene. And we know very little yet of the linkage relations among most of the characters that have already been analyzed. It is not exciting work, but it is work that must be done, and work that any competent geneticist can undertake. By simply following methods already laid down he can add materially to that genetic analysis of the hen which is our first essential. Moreover, there is always the chance of hitting upon a bit of knowledge that may open the way to more profound investigation if he keeps his eye open to indications of linkage phenomena. For instance, it is of great importance for us to understand the nature of fecundity, the genetic basis that underlies egg yield. This is one of those troublesome quantitative things that are so difficult to analyze. That it depends upon a number of genes is pretty certain. But how many there are, and what may be the separate effect of each, we can at present only surmise. Nor shall we know until we are in a position to isolate them and to test their effects on the bird, one by one. If, however, we found that in the F_2 generation of a particular cross a certain color or pattern tended to be linked with a definitely higher fecundity we should have begun to solve our problem. For by establishing such a linkage relation we should be in a position to isolate that particular fecundity factor and to study the individual effects of one member of our fecundity complex.

And here I would digress for a moment to consider a criticism that is sometimes launched at the geneticist by the so-called practical man. For what, he asks, is the good of studying all these trivial features—the detail of a comb, a spot on the head, or the pattern of a feather—when all the while the really important problems, such as the hereditary basis of fecundity, are left untackled? Why should not the geneticist devote his resources to these essential things instead of worrying about features that do not really matter? To which I would answer that this careful investigation of seemingly trivial things is really of the first importance. In the present state of our knowledge I see no more promising way of understanding the nature of such characters as fecundity or stamina than is afforded by the method of linkage. And to apply this with hope of success we must have an accurate knowledge of the inheritance of every visible character that can be dealt with. For this knowledge of the visible is the essential tool for the coming attack on the invisible. The more complete it is the more hopeful is our prospect for the coming attack. Therefore I would ask the practical man to have patience with the geneticist even though the efforts of the latter may at times appear to him to be ill-directed.

I admit that the fowl is not a favorable object for the study of linkage phenomena. Its chromosomes are too numerous, and most of them too small, whereas for the fruitful study of linkage, they should be relatively large and few. It is conceivable, however, that help may come from another quarter. X-rays have curious effects on chromosomes, sundering them at times and at others causing them to coalesce. If we could cause the thirty-odd small chromosomes of the fowl to coalesce into half a dozen larger ones, the study of linkage phenomena would be immensely aided. This is pure speculation, perhaps fantastic, for I have no idea whether it can be done. Still, if you meet a man irradiating the testes of a cock do not set him down as necessarily a crank. Keep a sympathetic eye on his work, for if he succeeds in bringing about a workable coalescence of the chromosomes he may well have wrought the industry a fundamental service.

In conclusion, may I touch briefly on another aspect of genetics—an aspect which concerns not so much the hen herself as the folk who cultivate her. The economic side of a great industry we all know to be of prime importance. But it is not everything. Man does not live by eggs alone. Unless he can take an intelligent interest in his work, that work degenerates into drudgery. It is here, in my opinion, that genetics can render its highest service. We live in a world at the mercy of advertisement and propaganda. To defend ourselves we have but one weapon—ascertained truth. It is with that weapon that genetics provides us. And when I speak of genetics I do not mean merely the corpus of facts set out in journals and textbooks. I am thinking more of the attitude of mind that has led to its accumulation—of the critical spirit that takes nothing on trust but is forever sifting and testing, separating the false from the true. If only for the sake of appreciating that spirit the story of genetics is worth following by all. Nor is there excuse on the ground of difficulty for it has been ably told by many writers. Moreover, he who masters that story will find something even more attractive—something for which, in one form or another, the world incessantly craves to color the drab of existence—I mean Romance.

WORLD-WIDE SIGNIFICANCE OF POULTRY DISEASES AND THEIR CONTROL

By PROF. DR. H. C. L. E. BERGER, *The Hague, Netherlands*

The times when poultry keeping was regarded by farmers as a side line, as something of secondary importance in farming, are long past. In those times poultry breeding was not the result of purposeful selection, of special direction of breeding. On the contrary, in general, mongrel poultry were kept, these being called "the farmer's hens." Not the least thought was given to the promotion of laying; neither was any attention paid to feeding or to hygiene. Nor was it necessary. The fowls produced eggs for the needs of the keepers and also as an article of commerce in the immediate vicinity, at the very most for the local market; they lived in close contact with their own surroundings, factors which made them strong and hardy. Gradually conditions became different, and a parallel might be drawn with the development of the breeding of our agricultural domestic animals. In this branch there had long been progress in the purity of the breeds and in increased production, combined with increased stamina by breeding methods, selection, rational feeding, and maintenance. This has also been the case in regard to poultry breeding of late years, a fact which has resulted in a great increase in the number of fowls and their products, primarily eggs both for consumption and hatching and secondarily, meat.

It is a known fact that especially in times of depression in the past and even, to a certain extent, at present, poultry husbandry as part of the farming industry has kept the latter going.

The great significance of poultry keeping nowadays is clearly illustrated by a few figures and statements. Dr. Cernaianu showed that the commercial value of poultry production in Belgium is greater than that of its metal industry; in the United States of North America the value of poultry products is 1½ billion dollars, which exceeds that of cattle by 200 million dollars and that of the corn crop by 300 million.

The importance of poultry keeping is also demonstrated by the exports of live and killed birds and of eggs. Germany, for instance, in the years 1937 and 1938, exported on an average about 32,000 tons of eggs, 1,450,000 live fowls, and 1,200 tons of killed poultry annually. Great Britian exported about 46,000 tons of eggs and 960 tons of killed poultry. In 1938 the Netherlands exported 1,150 million eggs. The value of the exports of eggs and egg products amounted to 40 million guilders and that of the exported poultry, 3.3 million guilders. Denmark annually exports more than 40,000 tons of poultry. In 1931 Rumania exported 2,300,000 live birds and 5,250,000 kilos of meat.

From these few random data one gains an idea of the exceedingly large numbers of fowls kept.

Is it surprising that endeavors are made to keep the birds as healthy as possible with a view to their production, and that every efiort is made to prevent mortality as much as possible?

The subject of poultry diseases is of great interest to State authorities and it also appears on the agenda of congresses, both those dealing with purely scientific subjects and those dealing with marketing in addition to disease. Also at the World's Poultry Congresses great attention has been devoted to the subject of diseases. There is a large attendance at the discussions of this subject and also at the general meetings where main reports are presented. And it is necessary. We know how closely the profitability of the industry is connected with disease and mortality, and we also know that the mortality has been increasing of late years in various countries, which fact is evidenced, inter alia, in the reports on the egg-laying tests. We need only to glance through the numerous digests from the International Review of Poultry Science of last year to see how high the mortality is in some countries, whereas in other countries it has remained within the normal limits.

As to the magnitude of the mortality I shall refer exclusively to the International Review, which shows that in the years of 1935–38 the mortality in the countries mentioned varied from 6.60 to 23.4 percent. Important reports on mortality appear in the Review.

It is not my intention to discuss here the causes of the increased mortality in detail, nor the diseases separately—this is done in the section concerning disease and hygiene. I need only to mention here the general lines which may lead to improvement in the combating of disease.

Before all, I consider a sound knowledge of the feeding hygiene necessary, for the acquiring of which continuous scientific investigations are essential; but in addition it is necessary to bring the knowledge acquired to the attention of the breeders and keepers of poultry and to the industry as a whole. As a matter of fact, a rational method of feeding is a preventive against numerous infectious diseases. In general, the large concerns employ persons who devote their time especially to hygiene, but in many small businesses there is much to be desired in this respect. Irrational feeding, in addition to striving to make the birds true egg-laying machines, is ruinous. As a matter of fact, with highly increased egg production the ovary becomes overworked, as a result of its intensive functioning. Such fowls, because of the strain on their vital functions, and resources, are consequently particularly predisposed to all sorts of infections and parasitic diseases. And frequently one will combat these diseases in vain if he tries to remove only the specific causes of the diseases and fails to eliminate the provocative causes.

As principal causes of mortality in many countries, coccidiosis—acute and chronic—paralysis, tuberculosis, pullorum disease, and paratyphoid may be mentioned.

With various diseases problems of great importance occur, involving the health of man as well as fowl. International cooperation of experts in this field is highly desirable. Although some investigators assume that a virus is the cause of paralysis, or neurolymphomatosis gallinarum, further study of the cause of the disease is advisable. In this connection attention might be paid to a possible connection with avitaminosis and leukemia.

Of late, paratyphoid has received special attention in the interest of public health, as a result of which in various countries measures are being taken in regard to the consumption of duck eggs. The effect of accurate methods of distinguishing carriers of germs, as well as the connection with paratyphoid in agricultural domestic animals, should be further investigated. As regards tuberculosis, more and more attention is being paid to the danger of infection for man and fowl.

In my report for the Sixth World's Poultry Congress I showed the task of the State Veterinary Services in various countries in regard to combating infectious poultry diseases and came to the conclusion, from an investigation in 28 countries, that the legislative control measures related in the first place to two diseases, cholera and fowl pest; that, however, in 22 countries other diseases are also being combated by the veterinary sanitary police; that practically the same measures are being used everywhere and that their basis is the compulsory notification of cases of disease. Further, I pointed out that practically all countries are trying to prevent the ingress of infectious poultry diseases by more or less strict legislative regulations governing the importation of live and killed poultry and of eggs.

Recently a special veterinary committee, of which I was a member, met under the auspices of the League of Nations and gave directions in this matter. I pointed out that in addition to the legislative compulsory control measures, there is also voluntary control, carried out by organizations in the poultry industry but supported and advised by the State Veterinary Service. Infectious diseases such as tuberculosis, paratuberculosis, mastitis, and abortion of agricultural domestic animals, which in some countries are not combated by the State by means of statutory regulations, are combated voluntarily by the related organizations, which have established so-called sanitary services for cattle in the various provinces. The State Veterinary Service cooperates in this work.

I cannot help thinking that a similar procedure might be followed in many countries where organizations of a high standard exist. Sanitary services for poultry might be established there—these already exist in a few countries—by means of which the combating of diseases may be centralized. The State Veterinary Service will have to lend its cooperation and support, an indispensable factor of which is the continual instructing of the poultry keepers. An important part of the instruction must be the hygiene and the care of the poultry.

In a good sanitary service the veterinary surgeon must, of course, play an important role. There are also required official veterinary laboratories, which examine sick and dead poultry free of charge, investigate and establish the nature of the disease, and prepare and supply serums, vaccines, and diagnostic agents. It must be borne in mind that the epizootology of poultry diseases are different in various countries, and even in the same country on various poultry farms, according to the hygienic conditions and management practices.

I repeat that with too intense production, in addition to the lack of hygienic measures in breeding, a favorable field exists for the development of disease-causing lower organisms. In case a disease breaks out at a poultry farm where such conditions prevail, the usual control measures will not yield satisfactory results. With physiologically exhausted fowls, an immunity obtained by vaccinations is only superficial and such immunity will generally fail to withstand an attack of the respective disease germs, whereas similar measures at poultry farms where attention is given to hygiene, where overproduction is avoided, and where proper feeding and management are practiced, will have the desired effect. Probably no branch of animal husbandry is so greatly affected by hygiene as the breeding and keeping of poultry. The words of Prof. Dr. Leclainche, director of the International Office, that "l'élevage se confond avec l'hygiène" depict in a striking way the position of the poultry keeping.

Just as in the control of infectious diseases of the agricultural domestic animals, namely, by international cooperation, so should it be with poultry diseases. The experts must have permanent international contact. For this purpose, besides the World's Poultry Science Association, the International Office for Contagious Diseases of Animals is particularly suitable. In my report already mentioned for your Congress in Leipzig in 1936, I explained the purpose and procedure of this world organization and mentioned the various subjects in the field of infectious poultry diseases and their combating which were dealt with there. In order to obtain the best results from this international veterinary institution, it is essential that the largest possible number of countries be members. At the present time 44 countries are official participants. In Europe, these countries include Albania, Belgium, Bulgaria, Cyprus, Czechoslovakia, Denmark, Germany, Finland, France, Great Britain, Greece, Hungary, Ireland, Italy, Lithuania, Luxembourg, Monaco, The Netherlands, Poland, Portugal, Rumania, Russia, Spain, Sweden, Switzerland, Turkey, and Yugoslavia. Countries outside Europe are

French West Africa, Union of South Africa, Algeria, the Argentine, Australia, Egypt, India, Indo-China, Iraq, Japan, Madagascar, Morocco, New Zealand, Palestine, Siam, Tunis, and Uruguay.

From this summary one sees a world organization in which the animal disease control activities of the various countries are united on a legal basis. And yet a few large countries are lacking, countries of a high standard of civilization, of high scientific development, also in the veterinary field; countries which are needed greatly in the great organization and which could do such an infinitely large amount of good by their official international cooperation.

As this international veterinary institution is of such great importance for the universal control of infectious animal diseases, and thus also for that of poultry diseases, I should like to elaborate somewhat on it.

The various countries have legislative regulations for the control of infectious cattle diseases. For years, however, these countries have not had any contact with one another in the matter. Neighboring countries did at times consult one another; were on their guard when there was a very infectious cattle disease of somewhat threatening aspect in the adjoining country, but yet there was no concerted cooperation. Furthermore, it was not known what diseases existed in the various countries or to what extent they prevailed, a condition which could constitute a great danger in view of the exports from the infected countries.

It has long been believed by the leaders of the State Veterinary Services of many countries that more mutual consultation as regards the control of infectious cattle diseases—especially as a result of the increasing international commerce involving export and import of animals and products of animal origin—is not only desirable but even essential; but this has not been carried out as completely as might be desired, owing partly to numerous factors beyond the control of these leaders. It is only necessary for something alarming to take place to cause action to be taken.

The event which was to be the direct cause of the coordinating action of various States was the following.

In August 1920 the greatly feared cattle plague was introduced into Belgium by Zebu cattle from India, which were destined for Brazil and which called at the port of Antwerp. This entirely unexpected, unprovided-for experience caused a commotion throughout Europe, due to the seriousness of the threatened danger. It also demonstrated that there is actually a close solidarity among all countries in respect to the danger of infection; that it is imperative to check the infective areas of diseases throughout the world and to make a joint study of their mode of spread and their control. This impulse was felt particularly in France. The Indian Zebu cattle had frequently been transported via Marseilles.

Prof. Leclainche, director of the Veterinary Services, was instructed by the French Government to organize an international meeting, which was held in Paris on May 25, 1921, and at which 43 countries of the Old and New World were represented.

The agenda of the meeting comprised the arranging for an annual conference for the study of epizootic diseases and their control and, the establishing of the international permanent office to centralize the information about the occurrence and spread of epizootics, to collect the documents relating to their study and to promote the respective research, to collect the results of the various control methods, and to study the matters which would be put on the agenda of the annual meetings.

The conference undertook the study of three diseases of an immediately threatening character: Cattle plague, foot-and-mouth disease, and dourine, and compiled a series of recommendations and suggestions. Resolutions were also passed regarding the method of publication of the veterinary health bulletins and regarding the compulsory health certificates for the export of animals and of products of animal origin.

Although entirely approving the suggestions of the French Government, the members of the conference expressed the wish that an "Office International" should be established for the control of infectious diseases, that the participating countries should appoint delegates, and that a permanent office in Paris should be established.

International regulations were drawn up, which specified the objects of the office and also the rights and obligations of the participating countries. By-laws were drawn up which explained the organization of the permanent office and its activities. The regulations were published on January 25, 1924, on which date 28 countries had ratified the convention. Since then, the number of participating countries has increased to 44.

The institute does not have the power to interfere in the laws of the various countries. However, it is entirely independent of the government of the country in which it has its registered office.

The governments notify the office in respect to measures taken by them for the control of infectious cattle diseases, particularly those measures to prevent the ingress of such diseases from other countries; they also furnish the office with any desired information.

The delegates constitute the committee; they elect a chairman and vice chairman for 3 years. At the first meeting in 1927 a director, Prof. Dr. Leclainche, was appointed. This meeting also fixed a tabulation of the occurrence of infectious diseases in the participating countries; it also decided on the diseases which should be incorporated in the tabulation.

A brief summary of the activities of the committee will give an insight into their extensiveness and their importance. For instance, in the 13 sessions from 1927 until this year, the following subjects have been dealt with:

Foot and mouth disease. Reports and discussions, as well as conclusions regarding biological control, serum, vaccination, plurality of the virus, resistance inside and outside the organism, cultivation of the virus, the course of the disease in the various countries, secret remedies.

Anthrax. Propagation by industries.

Swine fever. Diagnosis, vaccination, and results.

Tuberculosis. Preventive inoculation (B.C.G.), combating methods in various countries, synthetic tuberculin.

Infectious anemia in the agricultural domestic animals, particularly the solipeds.

Brucellosis. Etiology and control, control methods in practice, standardization of agglutination methods, fixing of titer for the diagnosis, transmission of the disease in the various kinds of animals and in man.

Rabies. Prevention and control, vaccinations.

Ostioc dystrophia of animals, disease of Aujeszky, helminthoses, and strongylidoses, tularemia, abortion, etc.

General subjects, such as carriers of germs, marking of animals from the point of view of veterinary sanitary police, modern technique of disinfection, treatment of cadavers and products of animal origin with a view to the control of infectious diseases and drafting of regulations, regulation of disposal of cadavers and waste products of animal origin, regulation of international transportation of animals by cattle wagons and motor trucks, disinfection of means of transportation, standardization of biological products, new aspects with regard to the control of infectious cattle diseases.

Poultry diseases. Since 1931 poultry diseases have been included in the discussions. Studies have been reported, inter alia, concerning bacillary white diarrhea; a magisterial report on *all* poultry diseases, their etiology, course, and control; helminthoses in poultry; vaccines against fowl pest, fowl cholera, avitaminoses.

It has been resolved to remain diligent in regard to poultry diseases.

I wish to point out that not only have the diseases, as such, and their control been studied, but investigations have also been made as to what conditions may favorably affect the diseases. For instance, there were two important reports which dealt with breeding, feeding, and maintenance (the method of care of the animals). The leading thought of these reports was that the occurrence of infectious animal diseases depends on the association of two factors: The animal must be exposed to infection, and it must be in a condition to take the infection, in other words, the infection must "take hold."

Veterinary surgeons throughout the world must make a careful study of the problems not yet solved. The knowledge gained so far enables us to improve appreciably the conditions under which the agricultural domestic animals, and also poultry, live and in this way to prevent the occurrence of infections and parasitic diseases or to exert a wholesome influence on their course.

The importance of the annual sessions of the Committee of the Office is measurable not entirely by a summary of its reports and activities. It represents, as it were, a Parliament whose advice is authoritative everywhere. Owing to there being only one official delegate from each participating country, the committee consists of a comparatively small number of learned men and administrators, all experts. It is the operation of these two factors which gives the office its originality and its authority. If the scientists come forward with new suggestions of a possibly hazardous nature, the practical men of the veterinary sanitary police consider the possibilities of the proposal and entertain only measures acceptable in the economic and social order. The resolutions resulting from the aforementioned work furnish the governments and the State Veterinary Services with the necessary directions.

The office in Paris performs permanent work; it is the organ both of information and documentation; its task is to follow, over the whole world, the prevention, the propagation, and the fluctuations of infectious diseases, to give useful information to the authorities of the various countries, and to publish the data thus obtained.

Apart from the information which the committee publishes in the veterinary health bulletins of the various countries, it makes investigations which show the current problems which merit study. The office publishes:

1. A monthly bulletin which contains, in addition to the original studies, data obtained from day to day about the sanitary situation of the various countries; publications of interest for the control of infectious diseases; extracts from or summaries of scientific works published in all countries; reviews of the subjects which have been placed on the agenda of the sessions of the committee or the study of which is recommended for the near future; copies of all texts (international conventions, laws, resolutions, decrees, and circulars) relating to the veterinary sanitary police of animals. Every year the whole comprises a volume of 1,000 to 1,300 pages.

2. The minutes of the annual sessions, which contain the reports of the director of the office on the state of animal health during the past year and, on the administrative and financial actions of the office; the reports obtained from the most competent persons, containing a provisional study of subjects which will be brought up for discussion; the records of the sessions, all of which form every year a volume of 400 to 600 pages.

3. The statistics on the infectious diseases collected according to the sanitary bulletins of the various countries. These documents, carefully classified, make a volume of 500 to 600 pages.

The foregoing brief review of an international organization which is in full activity may be considered sufficient to justify the appreciation granted to it by the Governments and by the scientific and agrarian millions of the whole world.

And this world organization in the field of controlling infectious animal diseases, in its session of 1934, after dealing with a highly important report on infectious poultry diseases, expressed itself as appreciating the necessity of assiduously continuing the study of epizootic diseases of poultry and their control, and stated that the Permanent Office would communicate, if there were reasons for so doing, with national or international organizations which occupy themselves with poultry breeding.

In the session of 1938 the following resolution was unanimously passed, without discussion:

The Office International des Epizooties, after its previous session, received an official invitation to send a representative to the Seventh World's Poultry Congress to be held in Cleveland, Ohio, in 1939.

The committee of the office is of the opinion that the office should appoint a delegate and allow him to attend said congress as the official representative of our organization.

The committee of the office decides that this delegation shall be entrusted to its president, Professor Berger.

DEVELOPMENTS OF MARKETING AND THEIR INFLUENCES ON THE WORLD'S POULTRY INDUSTRY

By Dr. Earl W. Benjamin, *New York, New York, U. S. A.*

Evidence points to the fact that the great changes which have taken place in our egg and poultry industry during the past forty years have been largely due to economic influences. Our Industry has passed through and left behind that field occupied by sportsmen interested in developing fighting stock or breeding for intricate coloration of plumage and constantly changing styles of body shape.

The struggle for life among mankind has been becoming more and more intense;—life for individuals as well as life for nations. Every available tool for accomplishing these desired ends is being utilized.

EGG AND POULTRY INDUSTRY CONCERNS ALL MANKIND

The egg and poultry industry is proving to be a very effective tool in this struggle for existence. No other Industry so completely commands the attention and concern of every people on the face of the globe. There are very few individuals who are not interested in either production or consumption of some kind of egg and poultry product. No other industry reaches so completely into the interests of the rich and the poor alike, children and the aged, women and men, the retired and the active. No other industry lends itself better to cooperative effort among those engaged in its activities—among those having common purposes. Earnest cooperation among people helps to weld them together and makes them more united and purposeful in their self-application to daily tasks. No other industry lends itself better to the job of making a nation self-sufficient. A busy people, producing a food product for their own consumption, are a happy people.

DEVELOPMENTS FOLLOWING THE WORLD WAR

During the decade following the World War there was everywhere an intense interest in bringing about a quick recovery from the economic drain of the world catastrophe. In the general spirit of the times, visions of the possibilities of such an undertaking as a World's Poultry Congress were spread before the industry by such leaders as Professor James E. Rice of Cornell University and Sir Edward Brown of London. Their dreams and plans, with the aid of countless enthusiastic supporters, were brought rapidly to fruition.

People concerned with the production and marketing of poultry products now come together from all parts of the world in triennial Congresses, for the purpose of developing and maintaining a unity of interest, a breadth of understanding, and a continuation of mutual benefits.

BASIC CHANGES TAKING PLACE

Aided by the World's Poultry Congresses and by the quickening of national endeavors of which the Congresses are merely a symbol, profound changes have taken place in our business of marketing egg and poultry products. I shall try to enumerate a few. First, I wish to acknowledge and voice my deep appreciation for the assistance given by many of you by supplying information relative to conditions in your own countries. Many who are not able to attend this Congress have also given me valued assistance. It is to the kindness of these friends of widely separated lands that I give credit for inspiring many of the viewpoints and opinions I have endeavored to express in this paper.

Sound and efficient marketing can be accomplished only when the product is being produced right. Marketing operations could not have enjoyed the progress and improvement which have been their lot during the past forty years except for equally important and beneficial improvements in the breeding of poultry to produce a more practical type of egg and fowl; better feeding to increase the production and improve the quality of the product; reduction of mortality and proper management to permit the production of infertile eggs for market purposes, making possible year-around supplies of fresh eggs and poultry meat products; as well as development along countless other lines.

Among the major developments directly affecting the marketing of egg and poultry products, and upon which most of the improvements in our marketing operation are more or less dependent are the following:

1. The adoption of more discriminating distinctions for sorting egg and poultry products according to various qualities.—A trend is evident toward adoption of more exacting grade specifications and application of the same all along the line from the producer to the consumer, wherever buying or selling is done. This probably has been the most important influence in the marketing of eggs and poultry products in the past four decades. It has provided an incentive for the producer to improve his products, because he can see the prices commanded by the different qualities of products in the market. He can see that to claim that a product is of a quality which it is not, becomes a boomerang.

Almost every country reports developments along this line. In some instances governmental authorities have done practically the whole work of conceiving the idea, devising the grading specifications and applying the same. In other countries the members of the industry, the producers, the distributors and the consumers have been consulted. Their suggestions and advice have been incorporated into laws and regulations, and a reasonable degree of enthusiasm has been developed for enforcement of the same. In still other countries the governmental authorities have done little, and the industry through their cooperatives or through voluntary associations and agreements have arrived at similar results.

2. An increasing appreciation for egg and poultry products for food use.—As the adoption of grading specifications became more general and these were applied to buying and selling operations, the quality of the egg and poultry products offered to consumers gradually became more dependable and more in conformity with the consumers' desires. This has been the experience in practically every country where efforts toward increased consumer appreciation have been undertaken. The authorities in Canada claim that a large share of the credit for their per capita consumption of 368 eggs per year should be given to the strict enforcement of their grading standards and the campaign of education which has gone along with that enforcement. Canada probably leads the world in per capita consumption.

In India the teeming millions of population average to eat a little under eight eggs per year, per person. In that country a substantial proportion of the population are vegetarians and do not believe in the taking of life for food purposes. A campaign of education is now being undertaken to show to these people of strong religious beliefs that eating an infertile egg does not violate their creed. We hope that consumption in India will show a rapid increase.

In the United States, and in England, Canada, and some other countries, the use of dried and frozen egg products for the commercial manufacture of baked goods, confections, mayonnaise and other dressings and other manufactured foods is rapidly increasing. A change in the baking and cooking customs of the people accompanies an improvement in the quality and a more dependable supply of these dried and frozen egg products. In the United States around 8 percent of our egg supplies are now marketed in frozen or dried form. China has been supplying about 85 percent of such products entering World Trade. The recent difficulties with Japan have interfered with the movement of Chinese frozen and dried egg products to some degree.

Turkeys, ducks, and geese, which formerly have been only festive dishes are now becoming available and being utilized more steadily and year-around in many countries. Improvement in the preparation and handling of all dressed poultry products is increasing the use of them.

3. Struggle for national security.—Many countries for one reason or another are seeing fit to set up trade barriers making it more difficult for egg and poultry products of other countries to move into their own national markets and compete with their home products. Efforts are being made by every possible means to encourage a more dependable domestic production of egg and poultry products so the country's supply of international exchange may be retained for the purchase of products which cannot be produced at home. We have noted a definite decline in foreign trade in egg and poultry products during the past decade. Of the twenty-three principal countries exporting egg and poultry products in the world, only two of the countries have shown increases in their export trade for such products since 1930. These two countries are Denmark and Australia. Every important importing country shows a decline in its imports of egg and poultry products since 1930.

We have already stated that the egg and poultry industry lends itself to a policy of self-sufficiency for countries in almost every climatic zone. Declines in the foreign trade of the world for egg and poultry products show that the countries are making use of this important fact.

4. Development of cooperative marketing.—Practically every country reporting on marketing developments and their influence on the poultry industry gives prominence to the efforts being made by producers and others to get together in various forms of cooperative undertakings for the purpose of improving their lot. Almost every operation in the industry lends itself to cooperative control. Cooperative organizations can do anything that the individuals making up the associations might do.

Most of the success of commodity cooperatives in the United States and in other countries can be credited to the fact that they were founded and developed because of necessity and the need of overcoming real and not fancied faults of the old system. Contrary to the belief of some very good friends in other countries and in this country I cannot believe that it is wise to promote or endeavor to maintain a cooperative through a religious sort of fervor for cooperative principles. A business cooperative is a way of doing business; it should be made to do business satisfactorily or individuals, who also deserve a living, should be permitted to do the business instead. There are nearly 200 business cooperatives handling egg and poultry products with a membership of over 100,000 persons and a business of nearly $100,000,000, in the United States alone; and these cooperatives have to succeed or stop business.

The so-called general consumer cooperative is quite different than the commodity business cooperatives I have just discussed. The consumer cooperative leading toward the Cooperative Commonwealth idea has been approaching the status of a social and political movement throughout the world and has no place in this discussion. In some European countries consumer cooperatives do a large share of the total retail food business, in Finland up to 40 percent.

The egg and poultry cooperatives thrive only where and so long as they are needed; and they should not survive such usefulness. It is my personal opinion that it is most unfortunate for the Industry and for the sound cooperatives when a government grants to cooperatives undue privileges which are denied to private initiative.

Sound cooperative efforts by producers of egg and poultry products in many countries are injecting a long-term interest into the improvement of products and methods, which the itinerant middleman cannot afford to do. Cooperative associations in the egg and poultry industry must assume the responsibility, expense and effort for much of the testing of new methods, and the first adoption of such as may be proven worthy. The cooperatives' control of volume and the life-time interest in the business of producing egg and poultry products inherent in their membership, makes it both possible and obligatory that the cooperatives do this missionary work even though the benefits immediately accrue to all competitors.

The cooperatives are important factors in many of the great changes in our Industry.

IMPROVED MARKETING METHODS

Continuous experimenting and searching to discover improved ways of marketing egg and poultry products are both the cause and the result of the four basic considerations which we have been discussing. Individuals and corporations everywhere are to be highly commended for their readiness to sacrifice personal and corporate gain, in their efforts to develop better methods for the general benefit of the whole industry.

I cannot take the time to discuss details of these changes in our practices, which we call progress; but you are more or less familiar with them, and if not, you all know where to go for information best fitted to your own particular need.

Quicker and better handling of the products, improved roads, better rail and truck equipment, and better use of refrigeration and other protective practices for the product from the time it leaves the farm until it reaches the consumer;—all these improvements are the product of initiative inspired by needs of the Industry or needs of the country. The improved practice of protecting the egg shell by treating it with a colorless mineral oil to prevent evaporation, loss of carbon dioxide gas and breaking down of the alkalinity of the egg has been of great economic value in this country. The egg case liner used in this country, consisting of asphalt treated paper accomplishes the same results to a lesser degree. Modern facilities for freezing or drying egg contents so the quality is conserved for use by bakeries and food manufacturers have been developed.

Improvements in packaging have been given careful consideration in all exporting countries due to pressure coming from their principal markets. The distributors in the British markets have been particularly active along these lines. In London, the egg market for the world, one finds every conceivable type of egg and poultry package. Baskets, flats, boxes of various sizes and all sorts of packing material are encountered in this great international market.

An urgent suggestion comes from the trade in London for the Seventh World's Poultry Congress to take some steps to bring about a standardization of the package and packing materials used for eggs throughout the world. Wood cases containing 30 dozen eggs, boxes of fibreboard or corrugated material containing 15 dozen eggs, packed with honeycomb fillers separated with molded flats, and the so-called fillerless flats are gaining strong popularity in the London market. This is being reflected by an increased demand for such packing materials in all countries exporting to the British Isles. These packages are well known in the United States, and we can expect important future developments along this line.

The importance of packing eggs with the air-cell end uppermost also becomes of commercial significance as the grading specifications in the markets become more exacting. The problem of determining the most practical method of cleaning market eggs is still receiving much attention. Research work has been done in Great Britain and other countries as well as in the United States on the full drawing and quick freezing of poultry and means of preventing freezer burning.

Improvements in methods of selling i.e. negotiating the sale and the transfer of the products from the seller to the buyer, have been developed along with the increasing dependability of the product, the lessened breakage in transit, and the gradual elimination of factors causing dissatisfaction between the seller and the buyer. Better selling means quicker selling, less costly selling, and more satisfactory selling. This means a closer relationship between the seller and the buyer, a more sympathetic reflection of the producer's problems through to the consumer, and of the consumer's problems back to the producer. The benefits resulting from improved selling are felt everywhere;—in the great public markets throughout the world; in the wholesale egg auctions, so prominent in Holland and used to some extent elsewhere in Europe and also in New York City; in the rural auctions which are so successful in Northeastern United States; and on the Exchanges where transactions are made according to specific grades. Easier trading means more trading, more production and more consumption.

The reporting of market conditions and prices obtainable in the markets for various qualities of products has been extended through radio service and cooperation of the local press in many countries. In order that producers and distributors may adjust their operations quickly through varying conditions of the market, it is important that accurate and complete information be distributed as widely as possible without undue delay.

GOVERNMENTAL ACTIVITIES

Some of the rapidity of the changes in the egg and poultry industry may be due to the trend toward greater participation by Governments in the economic life of many countries. In some instances this has come about because the Governments realize the value of a strong virile egg and poultry industry to their national defense programs and the morale and economic welfare of their people. In other instances the Government assistance has been due to the farmers' frantic grabbing at straws to help pull themselves out of the mire of economic depression. One often enjoys false hopes of pulling himself up by his boot straps, and if enough want to try it, they can force the Government to do it for them. Examples are misplaced confidence in visionary schemes for control of prices without proper regard for the old law of supply and demand; plans for control of production; and misleading labeling regulations. Egg producers particularly interested in fresh eggs sometimes urge regulations requiring the marking of refrigerated eggs as "cold storage." This term has such an effect on the consumer that she is unable to exercise her normal intelligence in choosing eggs and poultry which have been properly protected by refrigeration, for her use. In many instances these misguided actions are being rectified, and the authorities, in consultation with members of the Industry enjoying the confidence of these authorities, have been able to make some real progress in the right direction.

DEVELOPMENTS IN THE UNITED STATES

In speaking to the delegates to this Seventh World's Poultry Congress, I am speaking to guests of the United States. We hope that you will take occasion to observe at first-hand some of the various marketing developments of which I have been talking.

In the United States you see a country where probably about 25 percent of the egg and poultry products of the world are produced,—one country embodying great extremes of conditions affecting our egg and poultry industry. We have the heat of the tropics and also frigid areas constantly covered by ice; areas of almost complete aridity and also areas with some of the world's heaviest rainfalls. We have broad open prairies; mountainous and desert areas almost devoid of population, and we have some of the most congested residential and industrial centers of the world. Eggs and poultry are produced under varying seasonal and climatic conditions providing, under modern management practices, a fairly constant supply of fresh products the year around. All of these extremes of conditions and the tremendous volume of products are under one Government with freedom of trading between all sections, no problems of monetary exchange and different languages, and good highways everywhere. With easy transportation from one market to another, prices and supplies are closely related in all districts, permitting trading with relatively little risk. Adequate credit information is available. What you see here can hardly be compared with any similar volume of eggs and poultry in any other part of the world, where several different countries would be involved in comparable operation. It is natural that, under these favorable conditions in the United States, new ideas have been put to test very freely. Few obstacles have interfered with the adoption of whatever that is new may prove worthy. We hope you will be able to take time to give consideration to many of these developments while here.

THE FUTURE OF OUR INDUSTRY

Turning to our neighbor on the north, it is refreshing to find how simple a program can be worked out to fit a satisfactory egg and poultry policy to the purposes of that country. Canada has done four things according to the authorities there:

1. Established national standards for sale of eggs by grade.
2. Encouraged the carrying back to the producers of the premium established by consumer preferences in the market.
3. Transmitted information relative to market conditions to all those in a position to profit thereby.
4. Encouraged the organization of cooperative marketing organization, not for monopoly, but with the idea of creating and maintaining active competition in market activities.

Perhaps this program would not satisfy all countries and I am quite certain that it could not be adopted as effectively in many countries as has been done in Canada, where the type of people, climatic conditions, the competitive agricultural activities and the size of the country have been favorable to its application.

The egg and poultry industry has proven itself one of the basic activities around which a nation can build a sound agriculture.

Our experience in this country undoubtedly contrary to experience in some other countries is that, if the producers and consumers are left to their own devices in their efforts to produce and sell competitively on one hand and to buy and eat efficiently on the other hand, they will employ middlemen or develop cooperatives, utilize such Governmental help as seems necessary for educational and regulatory work, and will make a reasonable degree of progress with satisfactory speed and certainty. They will continually strive to make conditions better for each one individually, and in so doing they will help the whole.

Many of us in this country believe that the producer himself must carry the responsibility for building a better industry by increasing its stability, by promoting greater efficiency of the operations of production, handling, and selling, and by increasing the consumer appreciation for his products to a point where the Industry becomes truly a vital and indispensable part of our life and egg and poultry products become a necessity for our daily diet.

We producers in this country have not been able to do this, however, in spite of the fact that the distributors have offered to cooperate with us by selecting equitable funds on a per unit basis at various feasible contact points in the marketing channels. We producers are not yet ready to forget our differences and realize that what helps all helps each. We think we have a good idea here, but we do not seem to adopt it ourselves. We shall not be surprised if some of you producers in other countries go ahead and lead the way in this work.

ECONOMICS GUIDES OUR DESTINY

As stated in the beginning of this paper, I believe the great changes in our Industry will be brought about by economic conditions. Stomachs and purses guide our Industry. New methods of marketing will be adopted as soon as they are proven beneficial. It would be unfortunate if this were done before.

I believe the World's Poultry Science Association will do well to appoint an active committee to keep in touch with all marketing activities in the various countries and to interchange this information for the benefit of all. Tests of new ideas might be suggested where prospects for success seem most promising. Isn't there room for such work in a world where there are too many of us looking at each other through rifle peep-sights? —Where there is a place for a World's Poultry Congress, and it is up to us to do our best to maintain a place for such gatherings, there also is a place for such a marketing committee. I hope that at the business session of this Science Association such a committee will be set up.

In the work of these Congresses—in the work of such a Committee—lie opportunities for a profound influence on the egg and poultry industry of the world—on the relationship between the peoples of the world—in no other way possible of such effective accomplishment.

SCIENTIFIC PROGRAM

GENERAL SESSION

THE ADMINISTRATION OF POULTRY DISEASE CONTROL MEASURES IN THE UNITED STATES

By JOHN R. MOHLER, *Chief, Bureau of Animal Industry and Chairman of the Departmental Poultry Committee, United States Department of Agriculture, Washington, D. C., U. S. A.*

In view of the world scope of this Poultry Congress, I deem it fitting to comment briefly on certain international phases of the poultry industry of the United States. There is a common tendency, arising from feelings of nationalism, to regard various industries within a nation as the product of the efforts of its own people. This is a natural point of view. However, as we appraise closely the poultry industry of this Nation, and possibly other nations, we are likely to find many evidences of international influence. The most familiar is the diversity of breeds and varieties of poultry commonly observed on farms and at poultry shows and exhibitions. Here we see blood lines that originated in various countries of Europe, in regions of the Orient, and other remote places. It is true that there have been certain departures from the original plumage and types in response usually to selection and crossbreeding, but the original contribution is nevertheless in evidence.

INTERNATIONAL SPIRIT OF RESEARCH

Scientific investigation is another international contribution. It is axiomatic that research knows no geographical boundaries. Scientific workers of all nations have shared their findings with one another in a conspicuously altruistic manner. Thus, the successes that have attended efforts within the United States to improve poultry types, to safeguard health, and otherwise to build up a great poultry industry have been the result, directly or indirectly, of international assistance.

I welcome this opportunity to acknowledge the material and intellectual contributions of other countries to poultry advancement in the United States. And I sincerely trust that our friends from other nations may benefit also from the research findings and other contributions of the United States to the common pool of world knowledge and experience.

From personal observation in several countries in which poultry raising has become a prominent industry, I have been impressed by the methodical manner in which advancement occurs. This observation is especially true in the field of research. The number of discoveries or attainments which may be classed as brilliant or outstanding is relatively few, but through painstaking, methodical effort investigators in genetics, nutrition, pathology, and other fields have gradually increased the amount of useful knowledge. This knowledge, in turn, is gradually assimilated in the poultry-producing areas and by those groups that manufacture or supply feeds and equipment, or perform other services.

Thus the methodical attack on one problem after another has increased efficiency in production and has reduced the elements of risk and chance. Viewed in this light, the poultry industry of the United States, vast as it has now become with the gross income of approximately one billion dollars annually, rests on a very substantial foundation. It occupies an important position among the leading agricultural and livestock industries. Poultry raising has become one of the most stable and dependable sources of income for farm people. In recent years about 10 percent of the gross income from farming has been derived from poultry. And in localities where conditions of production and marketing are especially favorable, the poultry enterprise has reached large commercial proportions. In addition, poultry are raised in considerable numbers in suburban areas.

By these general remarks I have endeavored to convey my entire confidence in the soundness of the poultry industry and its ability to solve perplexing problems and difficulties. It has done so in the past; it is now making excellent progress against current difficulties; and with an accumulation of successes there should be no serious concern over the future. Human resourcefulness and accuracy of judgment depend essentially on adequate information. With increasing knowledge and experience our efforts should become increasingly fruitful.

DISEASE CONTROL AS ECONOMIC ALLY

Inasmuch as one of the objectives of this World's Poultry Congress is to discuss means of increasing the consumption of poultry and eggs, a brief reference to the role of disease in relation to that objective seems appropriate at this time. I consider disease control basic to the liberal use of poultry products, largely because of the economic factors involved.

Health and vigor are, of course, essential to production and there is ample evidence to show that profits increase at an accelerated rate as production rises above average. For instance, as annual egg production per hen rises from 100 to 200 eggs, the labor income increases not merely 100 percent, but close to 400 percent.

It is common knowledge also that poultry and eggs are constantly in competition with other foods, many of which supply desired nutrients at low cost. The intrinsic merits of poultry products, together with advertising, tend to overcome adverse price differentials. But if, through effective disease control, the poultryman can reduce his losses on the farm and produce more economically, then he is in a much better economic position. He will have more to sell and can afford to sell for less, without sacrificing net income. The result is a thriving industry. Disease control has a valuable effect also from the standpoint of human interest and reactions.

In the case of bovine tuberculosis, the nationwide campaign against that disease was accompanied by an increase in per capita milk consumption. Contrary to the fears of some interests, that the discussion of disease would create an aversion to milk, the facts now indicate the reverse situation. I believe that the public is entitled to know the conditions under which its food is produced. And when an industry is striving diligently to produce and market wholesome products, it soon receives the public's confidence and good will.

In the administration of poultry disease control in the United States, success has depended, in large degree, on good organization of the work and cooperation between public and private agencies. The United States Department of Agriculture and the State agricultural colleges and experiment stations conduct extensive research programs. Cooperating agencies are the State livestock and poultry officials, organizations of poultrymen, manufacturers of supplies, poultry publications, and other interests seeking the best development of poultry raising in all its ramifications.

POULTRY RESEARCH LABORATORY ESTABLISHED

In the exploration of new scientific fields, our research institutions utilize the joint efforts of trained workers having widely varying backgrounds. Great reliance is commonly placed on pathology, immunology, biochemistry, and related sciences.

These portions of the research field have been fruitful in the past and the products of such research have been highly dependable. Yet our poultry pathologists welcome the efforts of colleagues in the fields of nutrition, genetics, statistics, and other branches of advanced knowledge. The extent to which poultry can be raised and fattened in confinement is governed, we now know, largely by prevention of nutritional disturbances. Avoidance of vitamin deficiencies is especially essential. In the field of genetics, plant breeders have been conspicuously successful in developing disease-resistant strains. On the basis of such work there is considerable hope of success in improving our control over animal diseases. By virtue of their rapid sexual development and large numbers of progeny, poultry seem especially well adapted to research of this type as compared with the larger domestic animals which breed and multiply much more slowly.

An extensive project dealing with the ability of poultry to resist disease is now in operation at the newly established Regional Poultry Research Laboratory at East Lansing, Mich. This laboratory began operations early in 1939 and is concentrating its initial efforts on fowl paralysis. The causative agent of this disease is still unknown except that it is a filter passer.

Other infectious diseases of outstanding importance on our current research program are avian tuberculosis and pullorum disease. Next in economic importance is a group of pathological conditions, each of specific etiology, which constitute a serious menace to poultry life and health because of the damaging effects on the respiratory function. The principal offenders in this group of poultry enemies are fowl pox (diphtheria), infectious laryngotracheitis, and infectious rhinitis (coryza).

Conspicuous among the diseases caused by protozoan parasites are blackhead and coccidiosis. Worm parasites, including flukes, tapeworms, and roundworms, likewise impair the health of poultry and are included in research work. Effective control of lice, mites, and other external parasites is also a major objective.

The general manner in which disease-control agencies operate is typified by the avian tuberculosis project. In this case research showed the essential facts regarding the effects of the disease. The next logical procedure was to familiarize poultry owners with the symptoms and aid them in reducing losses.

SUPPRESSING AVIAN TUBERCULOSIS

The principal distribution of avian tuberculosis in the United States is limited to about a fourth of the States, chiefly in the central and north-central parts of the country, where the common practice is to permit poultry to run at large on farms.

For many years the Bureau of Animal Industry has endeavored to find a practical way to eliminate this disease, recognizing that any plan, to be successful, must be easy to apply. Accordingly, instructions were issued to the veterinarians engaged in the tuberculin testing of cattle to inspect the poultry flocks on the farms visited, to obtain information on the extent of this disease, and assist the farmers in its control.

When suspected birds were found, a post-mortem examination was held; and in case lesions of tuberculosis were demonstrated, the flock owner was advised on methods to be employed in removing the infection. The most practicable means of combating the disease in poultry flocks on farms were found to be as follows:

1.—If the flock is of the common barnyard class, the preferred method is to slaughter and burn all clinical cases and vacate the premises of all chickens for a reasonable time. The premises should be thoroughly cleaned and disinfected, and if the buildings are good, they should, if possible, be moved to clean ground. Restocking should be made with young chicks or mature birds from healthy flocks.

2.—A variation of the foregoing method is to cull and slaughter all clinical cases and keep the remainder of the flock, which preferably consists of young birds, in uninfected fenced quarters. Restock with day-old chicks and raise them in an inclosure on clean ground.

These plans may be extended to provide for the testing of all flocks in which clinical cases are not found, to give additional assurance of freedom from tuberculosis. Each plan provides for a general educational campaign.

The plans do not apply to well-managed purebred breeding flocks, which are not frequently infected. However, when they are, the entire flock should be tuberculin tested frequently, reactors eliminated, and houses and runs disinfected until the disease no longer exists. On the average farm, it is necessary to consider the flock instead of the individual birds as a unit, because the infection may remain in the soil for several years and may be a source of danger.

The veterinarians engaged in cattle tuberculosis-eradication work have observed approximately 20,000,000 fowls annually. In areas where tuberculosis-eradication work in cattle has been largely completed, it has been necessary to assign a group of veterinarians—about 15 in number—to the avian-tuberculosis project, with no other duties to perform. These men are doing very effective work.

Avian tuberculosis causes losses not only in poultry but also in swine that become affected with this disease by eating badly diseased fowls or their droppings. About 10 percent of the swine in some localities are affected with avian tuberculosis, usually to but a slight degree. It is noteworthy that the area where most of the avian tuberculosis in the United States is found is also the area where most of our swine are raised. For this reason the control of avian tuberculosis in that area has an important bearing on the swine industry as well as on poultry production.

The general outlook for the control of tuberculosis in poultry in the United States is distinctly favorable, as a survey has shown the disease to be materially reduced by the methods described.

CONTROL OF PULLORUM DISEASE

The activities of the Bureau of Animal Industry pertaining to the control of pullorum disease are largely connected with the National Poultry Improvement Plan, which was inaugurated July 1, 1935. Under the cooperative guidance of the Bureau the plan is operated voluntarily and independently in each participating State, under authority of a designated agency.

One phase of the plan pertains to the breeding of flocks and management of hatcheries, and deals with such varied problems as hatching, advertising, sales, and sanitation. In another phase of the plan, which relates to the control of pullorum disease, three classes of flocks are provided for, namely, pullorum-tested flocks, pullorum-passed flocks, and pullorum-clean flocks. In the pullorum-tested class there is a tolerance of pullorum reactors up to, but not including, 10 percent. This means that before such flocks can be used for breeding purposes one or more additional tests must be made to bring the number of reactors within the tolerance allowed. In some States this 10-percent tolerance has been reduced on the initiative of the official State agencies with prospects, in the near future, of a reduction to 5 percent or less at the request of the States participating in the National Poultry Improvement Plan. No tolerance is allowed in the remaining classes. Annual tests are required for the pullorum-tested and pullorum-passed classes. However, for entrance into the pullorum-clean, or highest, class, two consecutive clean tests are required not less than 6 months apart, the last test being made within the testing year immediately preceding the date of sale of hatching eggs or chicks.

All pullorum-disease testing, within the plan, is done under the authority of the respective States, by one of three recognized agglutination testing methods, namely, (1) the stained tube agglutination test, (2) the stained-antigen rapid whole-blood test, (3) the rapid serum test. Since the development of the stained-antigen rapid whole-blood test, the Secretary of Agriculture has granted permits to more than 30 commercial laboratories for the manufacture of the stained antigen. The Department of Agriculture has accepted the responsibility for examining commercial stained antigens to be used in the rapid whole-blood test. Such supervision is commonly regarded as a safeguard to the reliability of pullorum-control work in States using such antigens. Tube or rapid serum antigens are prepared, for the most part, in the respective State laboratories and do not come under Federal supervision. The majority of States are conducting some phase of pullorum-disease control with the immediate objectives of improving the hatchability of eggs and the livability of chicks.

SUPERVISION OF POULTRY BIOLOGICS

In addition to the supervision of commercial stained antigens, as already noted, the Bureau of Animal Industry administers the Virus-Serum-Toxin Act, passed by Congress in 1913. This legislation provides for the production of veterinary biological products under a system of licenses and related Federal supervision to insure the purity and potency of such products. Prominent among the biologics produced by licensed establishments for poultry use are fowl-pox vaccine, laryngotracheitis vaccine, roup bacterin, typhoid bacterin (avian), mixed bacterin (avian), hemorrhagic septicemia bacterin (avian), pullorin, and avian tuberculin.

TESTING OF DISINFECTANTS

In dealing with disease problems, poultrymen have had the benefit of technical aid in their selection and use of suitable disinfectants. For many years the Bureau of Animal Industry has studied the effectiveness of chemicals likely to be of value in destroying disease organisms. In addition, it has tested commercial disinfectants and prepared lists of those approved for specified purposes. These studies have provided helpful information not only concerning the germicidal power of different products, but also on such other points as safety to operators, residue odors, corrosive effects, and similar practical considerations. The investigations have emphasized also the importance of thorough cleaning of all surfaces to be disinfected.

As the principal veterinary unit of the United States Department of Agriculture, the Bureau of Animal Industry has conducted the activities outlined thus far in this discussion.

POULTRY FUNCTIONS OF OTHER DEPARTMENTAL BRANCHES

Other branches of the Department, however, have functions that involve various phases of poultry production, marketing, and disease control. Following is a summary of their activities, which relate directly or indirectly, to safeguarding the health of poultry.

FEDERAL SUPERVISION OF DRUGS AND RELATED PRODUCTS

Producers of drugs, insecticides, vitamin preparations, and other products used in treating poultry diseases, in feeding, or in management of flocks, are subject to Federal supervision under the Department's Food and Drug Administration. This work includes periodic chemical and vitamin assays of cod-liver oil and other vitamin products used for poultry feeding, and the collection and chemical analysis of samples of poultry remedies and poultry insecticides obtained from interstate shipments. In case any of these products fail to meet certain standards or if they do not accomplish all that the labeling claims, they are subject to removal from the channels of interstate trade. The Food and Drug Administration, in the enforcement of the Food and Drugs Act and the Insecticide Act, also carries on investigational activities, such as the investigation of proprietary poultry-parasite remedies, insecticidal remedies, and other products.

INSPECTION OF DRESSED POULTRY

In connection with official grading, inspection, and certification of poultry products, the Bureau of Agricultural Economics maintains a dressed-poultry inspection service. There is no requirement that dressed poultry moving in interstate commerce shall be federally inspected. The grading service is rendered, therefore, to concerns that request it and where the necessary arrangements for such a service can be made. The company using the service must pay to the State agency with which the Bureau cooperates a sum sufficient to finance the cost of the service rendered. It must also meet the requirements of the Bureau with respect to methods and equipment.

The inspection rendered consists in the examination of each poultry carcass at time of evisceration to determine its wholesomeness and freedom from disease. This work is done by qualified veterinarians who are licensed by the Department and receive their salaries from the State agency with which the Bureau of Agricultural Economics cooperates in the inspection service. This service is conducted at approximately 30 points in the States of Massachusetts, New York, New Jersey, Delaware, Pennsylvania, Indiana, Illinois, Nebraska, Minnesota, Iowa, and Washington. At these points the poultry used by canning plants or the poultry prepared for sale as full-drawn poultry receive inspection.

INSPECTION OF LIVE POULTRY

The Bureau of Agricultural Economics also maintains a live-poultry inspection service at New York City, New York, and Newark, New Jersey. At these points trained inspectors examine the live poultry on arrival at the market and before sale to slaughterhouse operators. The inspection, made by sampling, takes into account the health condition of the birds and the size of crop. Poultry found to be in an overcropped condition must be held for a later inspection in accordance with the rules governing this service. Poultry that are diseased or otherwise unfit for food are denatured or destroyed. The inspection service at these two points is carried on in cooperation with the New York State Bureau of Markets and the New Jersey Department of Agriculture, respectively.

INFORMATION SERVICES

As a part of economic investigations of the production and value of poultry, the Bureau of Agricultural Economics obtains monthly reports from crop correspondents who furnish poultry data from more than 20,000 farms. At certain seasons the reports include data on the mortality of birds. Commercial poultry and egg producers likewise report mortality data. The combined records provide the means of noting any unusual conditions regarding deaths of poultry on farms and in specialized poultry establishments.

In the Bureau of Entomology research work has developed practical methods of controlling the more common external parasites of poultry. Information on these subjects is supplied by letter and publications from the administrative offices in Washington, D. C., and also by field stations. With changing methods of poultry husbandry new problems arise in the application of control measures. These receive consideration so that poultrymen may be reliably advised.

For the distribution of information the Department of Agriculture has a well-developed extension system, together with press, radio, and publication services. This work is largely coordinated with similar units in the States.

In connection with its press and radio services, the Department maintains a seasonal schedule so that information on control measures may be timely. For instance, in most parts of the country blackhead disease causes the heaviest losses in turkeys in June and July, and again in the late fall months, October and November. Pullorum disease in chicks is most troublesome from January to May, inclusive, and during November and December. Fowl cholera is especially serious from April to September, inclusive.

SUPERVISION OF IMPORTED POULTRY

The discussion thus far has concerned poultry diseases of the United States and methods of combating them. Attention is given likewise to possible infection originating in foreign countries. European fowl pest has invaded the United States on a few occasions. Prompt action by cooperating Federal and State veterinary officials eradicated the outbreaks. The method consisted in tracing the source of infection to all premises involved, followed by the destruction of infected birds and the thorough cleaning and disinfection of premises, coops, and conveyances.

FLEXIBILITY OF DISEASE CONTROL

In closing I wish to emphasize the flexibility of the measures used in dealing with particular lines of work. No two problems are alike and accordingly each case is dealt with as circumstances warrant. In the case of research work we endeavor to bring all available science into a focus on the problem. When the necessary facts are available the next general step is to publish the research findings promptly and then give wide dissemination to means of application. This so-called educational phase of the problem is supplemented, in the case of the more serious diseases, by inspection work on farms, in markets, or both. In serious diseases having the threat of an epizootic, such as fowl pest, there is a prompt marshalling of veterinary forces under Federal and State authority so that spread of infection is prevented. Thus the general system of poultry-disease control in the United States is essentially one of applied science, administered by public and private interests working in close cooperation.

SOME CONTRIBUTIONS OF RESEARCH TO THE POULTRY INDUSTRY

By L. E. Card, *Professor of Poultry Husbandry, University of Illinois, Urbana, Illinois, U. S. A.*

It is no small honor to be invited to address the general scientific session of this, the Seventh World's Poultry Congress, and I am deeply appreciative of the privilege and the opportunity which have been accorded me by those in charge of this session. In presenting for your consideration some thoughts on the contribution of research to the poultry industry, I shall try to show what some of the more important findings have been and to suggest a few applications of these and future results of research to the problems with which poultrymen are confronted.

Scientific research, as it affects the poultry industry, has become so broad and so complex that no individual can hope to be fully conversant with all its ramifications, nor even to understand all its findings and applications. I can think of no more certain way of becoming aware of this than to undertake the preparation of a paper on some such topic as that which has been assigned to me.

Because the problems are so many and so varied, those selected for discussion here have been grouped under the headings of genetics, incubation and embryology, nutrition, physiology, endocrinology, husbandry practices, marketing, and poultry-farm management. Health problems and poultry-products research are being discussed separately by Dr. Mohler and Dr. Pennington, respectively.

RESEARCH IN GENETICS

The scientific approach to the problems of poultry breeding is a comparatively recent development, but it has been pursued with such diligence and effectiveness that more is known about the genetics of the fowl than about the genetics of any other food-producing animal. It is fortunate for poultrymen that the chicken has proved to be well suited to genetic studies. This fact has made it comparatively easy for the geneticist to become interested in the practical problems of poultry breeding and to appreciate their significance to the industry.

A vast amount of research must yet be carried out before we shall know the complete story—if indeed that ever becomes a reality—but the poultryman of today has at his command a great fund of exact genetic information, whereas the poultryman of 30 years ago had nothing but practice to guide him. As knowledge of the facts becomes more complete and more nearly universal, conscious use of the underlying principles becomes more general, and poultry improvement can proceed at a more rapid rate.

Significant among the contributions of the geneticist is the demonstration of sex-linkage and its wide application to the production of chicks which can be easily and positively separated according to sex at hatching time. When sex-linked characters are used in place of cloacal examination, the common complaints from purchasers of sexed chicks are largely eliminated because the customer can see the differences between cockerel and pullet chicks when he takes delivery and there is no chance for an argument at a later date over the possibility that some cockerels were deliberately included in an order for pullet chicks. The possibilities and prospects for auto-sex-linkage within breeds are to be discussed by Professor Pease of England in one of the later sectional meetings.

Much of the recent work in poultry genetics has been concerned with physiological characters, and the results are likely to be extremely valuable in their practical application. The nutrition worker may sometimes feel that a test has been a failure unless all the chickens in a given lot show symptoms of deficiency when placed on a supposedly inadequate diet, but cooperation with the geneticist may lead to a demonstration of hereditary differences in respect to either minimum requirements for a certain nutrient or susceptibility to the effects of particular diets.

Preliminary findings have already indicated rather wide variations in minimum requirements for vitamin D, and recent experiments both in this country and in Europe have shown that White Leghorns differ from Rhode Island Reds and Barred Plymouth Rocks in possessing as a hereditary breed characteristic a marked resistance to a deficiency of vitamin B_1. More investigations of this sort are needed, and it is not unlikely that important results will come from such studies.

Research in poultry breeding may aid greatly in solving the most pressing problem confronting poultrymen at the present time, namely, the high mortality among pullets after they reach laying age. Much of this mortality results from conditions for which there is no known causative agent and for which there have yet to be developed effective control measures. There is increasing evidence that selection and breeding on a family or progeny basis will bring significant improvement within as short a time as 3 or 4 years. If stringent in character and specific in application, such selection should produce stocks which are much more valuable for commercial purposes than are most of the stocks in existence today.

Another phase of poultry breeding which should receive increasing attention, because of both economic necessity and the encouraging results that have already been reported, is selection for the ability to maintain profitable egg production over a period of several years. The expense of replacing a large percentage of the flock annually arises not only from high first-year mortality but also from the rapid decline in egg yields after the first year which, in turn, makes it imperative to have a high percentage of pullets in a commercial flock. A gradual change in this condition may be expected in the future, as research in genetics points the way. The automatic selection for longevity which is introduced by the practice of breeding from old stock helps to lower the pullet mortality while at the same time it builds a basis for longer reproductive life.

INCUBATION AND EMBRYOLOGY

In what may be called applied embryology we have an excellent example of how practical industry problems serve to focus the attention of research workers. Extensive development and expansion of the hatchery business have been possible only as public and private research has determined the limits of tolerance for developing embryos with respect to temperature, relative humidity, oxygen, and carbon dioxide. The application of these findings has resulted in the construction of mammoth incubators which are largely automatic in operation and which control the various environmental factors within very narrow limits.

Much progress has also been made in determining the exact nature of embryonic mortality. It is frequently possible for a trained observer to discover the cause of low hatches from a detailed examination of the unhatched embryos. Certain malpositions and definite peaks in the mortality curve are sufficiently characteristic of corresponding environmental conditions to be almost diagnostic in their significance. We have come far from the conditions of 1851 which led one American writer to comment as follows:

> Within two or three years past, an apparatus has been exhibited, from time to time, in the city of New York, called the American egg-hatching machine. It is stated that it has been examined by a large number of practical and scientific men, who have strongly attested to its usefulness and general adoption.
>
> This machine is constructed of tin, or other materials, with the brooding chamber surrounded by water, warmed to a suitable temperature by means of a spirit lamp, which, it is said, may constantly be kept burning for less than ten cents a day! The whole apparatus does not exceed two and a half feet in length and depth, and is stated to be capable of hatching from 200 to 600 chickens at a time, with a loss of not more than two per

cent, if the eggs are perfect, and if proper attention is paid to the temperature of the machine! But here let us drop the subject. In my humble opinion, all these ingenious imitations of, and interferences with, nature, though they may flourish for a day, (and flourish they cannot be said to do), will pass away as things that were.

That old incubator has long since passed away, but its descendants are with us in enormous numbers. Furthermore, in spite of all the improvements which have taken place in incubator design and construction, the annual toll of eggs which fail to hatch is no less than 30,000,000 dozen, or 2,500 carloads, in the United States alone. Clearly, the hatcheryman's problems are not yet completely solved. Much remains to be done, both in actual research and in the practical application of accumulated findings to field conditions.

It is probable that the most effective research on these problems will not be concerned with incubator operation or environment, nor with the care of eggs saved for hatching, but rather with the breeding stock from which the eggs are produced. The geneticist will be able to make additional important contributions through the identification and elimination of lethal genes, and nutrition workers will undoubtedly find further evidence of the favorable or unfavorable effect of specific dietary constituents on reproduction and hatchability.

NUTRITION

Successful feeding practice is much more complicated and, as a rule, more difficult than it was a few years ago. Rapid growth is demanded and higher and higher egg yields are sought. In consequence, the nutritive needs of fowls have become more and more exacting while the available feed supply has become more variable in kind and quality.

Early hatching for the production of laying pullets and the raising of winter broilers have made it necessary to obtain increasing numbers of eggs for hatching during the winter months, and this has directed specific attention to the nutritional requirements of breeding hens. It has become very clear that modern methods of feeding and management, although they have contributed much to the establishment of a prosperous industry, make it essential that poultrymen have an understanding of, or at least know how to apply, the findings of scientific research.

Someone has said that the two most important discoveries in agricultural research are Mendel's law and vitamins. Certainly the one has been the stimulus to much detailed research on the genes and their effects, whereas the other typifies the painstaking and exhaustive inquiry which is being made in the field of animal nutrition.

The optical measurement of vitamin A potency, the artificial preparation of at least eight forms of vitamin D, and the establishment of the chemical nature of riboflavin are specific examples of comparatively recent accomplishments in the study of vitamins, which are important in poultry feeding. Still more recent is the discovery of pantothenic acid and the finding that it is important in the diet of the chick. It has even been suggested that this is the universal vitamin, that it is necessary for the nutrition of all the higher forms of animal life as well as for numerous plant forms, and that it makes up an essential part of every living cell.

The growth requirements of the chicken have been studied and measured in terms of the daily deposition of gross energy, protein, and minerals in the new substance added during growth. The shape of the growth curve as related to time, to total feed intake, and to the composition of the ration has been rather accurately evaluated, so that we know just about what sort of performance to expect under any given set of conditions. We even have rather definite ideas as to maximum growth rates and optimum levels of protein and certain minerals at different stages of growth. In fact, we probably know more about the specific nutritive requirements of the fowl than about the feed requirements of any other domestic animal.

Important findings have also been made with respect to the effect of feed ingredients on the quality of poultry products. Some of these findings, such as the effect of feed on yolk color, have led to extreme recommendations and practices, but time can be depended upon to correct these errors of judgment. The significant point is that research has provided the answers to many questions concerning the specific effect of feed on eggs and poultry meat.

PHYSIOLOGY

There are a few investigators, with a genuine interest in the hen and the egg, whose intellectual curiosity takes the form of a consuming desire to understand the why and how of normal physiological functions in the fowl. It is probable that when the history of poultry research is finally written this group of workers will have given us some of the most valuable results in the entire field.

The physiology of reproduction offers many intriguing problems for study. Calcium metabolism is an excellent example. How is it possible for a high-producing hen to put out in eggs every 8 to 10 days as much calcium as is contained in her entire body, and to continue to repeat the performance for a year or longer? What mechanism controls this highly efficient shell-forming system so that the process is stopped when the shell is scarcely one-third of a millimeter in thickness? Why doesn't the hen occasionally or frequently make an eggshell which is 2 to 5 millimeters thick?

How does it happen that the forming egg in the oviduct always lies with the small end foremost as it proceeds down the reproductive tract? How does the germinal disc become oriented so that only rarely does the embryo develop in other than what we choose to call the normal position with reference to the long axis of the egg? What is the exact stimulus which touches off the process of ovulation? These and many other questions must be answered before we can say that we understand the processes which are continually taking place within the body of the fowl.

The surgical approach to physiology in the fowl, made possible by the development of new and easily used anesthetics, has added much to our knowledge of normal functioning of the reproductive and gastro-intestinal tracts. Numbers of hens have been kept in laying condition after operative removal of various portions of their oviducts. Artificial ova have been introduced into the funnel of the oviduct and have subsequently received a full complement of white and shell. Constrictions have been placed in the upper part of the oviduct, and some hens so treated have laid yolkless eggs without the stimulus which might be supposed to come from the presence of a yolk.

The time required for the various steps in egg formation has been accurately observed in surgical subjects by marking the position of the egg at 15-minute intervals. Eggs have been removed from various portions of the oviduct in order to determine their exact physical and chemical composition at different stages of development, and those from the isthmus and uterus have been carried to completion outside the body of the hen, at least for the addition of thin white and the formation of chalazae. Perhaps some enterprising physiologist will soon demonstrate that a hard shell can be added to such an egg without any assistance from the hen.

These examples are sufficient to show that the physiology of egg production is receiving considerable attention at the hands of research workers, and to suggest that much helpful information will probably be uncovered during the next few years.

Physiology is likewise an essential part of the study of nutrition in the fowl, and nutrition workers are making good use of surgical and other physiological techniques in the solution of their many problems. A comparison of digestion coefficients for coarse and ground feeds in gizzardectomized and normal fowls has shown conclusively that the gizzard functions primarily, and probably solely, as a grinding organ. Fowls from which the gizzard was surgically removed have lived for 3 or 4 years in apparently normal condition, showing that the gizzard is not essential to health. Similar operative procedure can and no doubt will be used to study the specific functions of other parts of the alimentary tract of the fowl.

Radiological observations of the digestive tract have been helpful in providing information concerning its function. Most of such observations have been made by the use of barium salts in the lumen of the tract, but a recently developed technique involves the injection of a colloidal suspension of thorium dioxide directly into the walls of the organ to be studied. This procedure has been used with the crop, gizzard, and uterus of the fowl and gives promise of furnishing new information about the activity and movements of these organs.

The physiological response of the hen to various environmental conditions has become important in the practical control of egg production, especially through the use of artificial illumination. Hens can be made to lay all their eggs at night instead of all during the day, or they can be made to distribute their production uniformly throughout the day and night, simply by adjustments in the light schedule to which they are subjected. Furthermore, they can be made to shift promptly, i.e., within 3 or 4 days, from day laying to night laying if the light schedule is suddenly reversed.

The idea that the longer feeding day which frequently accompanies the use of artificial light is important in bringing about increased egg production has been completely refuted. In fact, recent experiments have shown that, with the right sort of rations, hens can maintain their weight and continue to lay at a reasonable rate when their feeding time is restricted to a maximum of 1 hour in each 24, or to two 20-minute periods approximately 12 hours apart. There is no reason to suppose that such findings will have any immediate or marked effects on feeding practices, but they will help to clarify our understanding of how the hen responds to her environment and may be distinctly helpful in evaluating suggested new practices which are often disturbing to the progressive flock owner.

ENDOCRINOLOGY

The glands of internal secretion exert a profound influence on the appearance and functioning of animal organisms, and the fowl is no exception. Experimental studies have shown that quantitative variation in the secretion of various hormones by these glands is responsible for such things as the onset or suppression of broodiness, the beginning or end of a period of egg laying, the onset or retardation of the molt, sex dimorphism in shape and color of feathers, the activation of the testis and ovary, and the level of blood calcium.

The hypophysis, or pituitary body, is of special interest because of the several hormones which it secretes and because of their different effects. The gonad-stimulating hormone from the anterior lobe of the hypophysis is responsible for the activation of both the testis and the ovary in the fowl. Secretion of this hormone is stimulated by increasing the amount of artificial light which the fowls receive. Activation of the ovaries, which occurs when nonlaying hens are brought into production by the use of artificial light, results in increased secretion of the ovarian hormone. This in turn induces changes in the head furnishings, causing the combs and wattles to become red and waxy. If now these hens be injected with prolactin, another hormone from the anterior lobe of the hypophysis, they will promptly cease laying, their combs and wattles will shrink and, if they possess the genes for broodiness, they will begin clucking, will remain on the nest and, in short, will exhibit all the characteristics of a naturally broody hen.

Toward the end of summer the decreasing length of day affects the hypophysis so that there is decreasing production of the gonad-stimulating hormone. This in turn permits a reduction in activity of the ovary with a decrease in egg production and lessened secretion of the female sex hormone. Reduction in the amounts of these two hormones apparently permits increased activity of the thyroid gland with consequent greater secretion of thyroxin which, in turn, induces molting. A nice balance among the several endocrine secretions is necessary if the hen is to perform as man wants her to perform rather than as Nature intended. Research in endocrinology is providing the basis for partial control of this complex regulatory system.

HUSBANDRY PRACTICES

Husbandry methods and practices have been influenced in various ways by the findings of research, chiefly as scientific investigations have developed and made clear the underlying principles which could be used in evaluating both old and new practices. Feeding methods, for example, have been altered in order to provide better sanitary conditions, and the same is true of rotating yards and ranges, renewal of litter in brooder houses, and other related practices.

Insulation of poultry houses has gained favor because of its practical possibilities for increasing winter egg production, but fundamentally it is based on the desirability of keeping the hens' environmental temperature above the critical points, which research has indicated as being about 15° F. during the day when the birds are active and 40° F. during the night when they are at rest. Insulation is also of some value in keeping summer temperatures below the point (approximately 85° F.) at which egg size is unfavorably affected. Artificial cooling of poultry houses in summer has not been used extensively, though there are indications from rather limited tests that it may be practical and advantageous in those sections of the country where the humidity is low enough to permit the evaporator types of coolers to work efficiently.

Complete air conditioning has not found a place in poultry management except where large numbers of young chickens or laying hens are kept in batteries under conditions which materially reduce the cubic air space per chicken as compared with the limits usually found in ordinary brooder or laying houses. There is need for additional experimental work to determine the optimum temperature, ventilation, and humidity conditions for fowls kept in confinement.

The selection of hens for egg production on the basis of external characteristics is an outstanding example of the influence of research findings on poultry-husbandry practice. Information on this subject has been so widely disseminated that nearly every farm boy and girl knows how to apply the principles of production judging. The importance of sunshine for growing chicks, the value of cod-liver oil in winter feeding of poultry flocks, and the place of milk in the ration of breeding hens are examples of other practices which are so widely accepted that the average flock owner gives little if any thought to the research which preceded them. Can we ask for any better evidence than that the time and money spent for research in poultry husbandry are yielding a magnificent return? And as a corollary, should we not derive from that very fact a suggestion of caution lest we, in our enthusiasm, give flock owners the impression that all our latest findings are equally important and worthy of their immediate acceptance? Perhaps never before has the poultryman needed as much sales resistance, in the sense of a calm determination to give careful thought to suggested new practices before making them his own.

MARKETING

Much valuable research has also been conducted in the field of poultry and egg marketing. We have learned that consumer preferences in the matter of visible egg-quality factors are based chiefly on the desire to be assured of high interior quality. Many consumers are willing to pay a premium for eggs of large size or for those of known freshness, and most persons who buy top-grade eggs do so frankly because they are presumably the best eggs obtainable.

As a result of research on egg quality we know how most of the deterioration in quality occurs and, what is more important, we know how to prevent it. Increase in shell porosity, shrinkage caused by evaporation, liquefaction of the white through enzyme action and loss of carbon dioxide, and weakening of the yolk by osmosis, have all been studied in more or less detail. All can be retarded by suitable holding conditions.

Certain other quality factors, such as egg size, thickness and quality of shell, and percentage of thick white at the time of laying, are hereditary characteristics of individual hens and have been shown to be capable of improvement by selection. Repeated attempts to improve these characters by feeding have served to confirm the conclusion that the practical approach to improvements in the quality of fresh-laid eggs is through the findings obtained by genetic and physiological research.

Investigations dealing with factors affecting the quality of poultry meat have been less extensive, but some significant findings have been made. The fundamental importance of selecting breeding stock on the basis of the conformation best suited to quality in market poultry has been clearly demonstrated, and the advantage which certain crossbreds possess in uniformity of development and in rapid growth has been accepted by many commercial broiler producers.

Studies have been made of the effect of feed ingredients on fleshing, finish, and distribution of fat over the carcass, but practical application of the results has been greatly hindered by the fact that so much of the stock going into feeding stations in recent years would not stand more than a few days of intensive feeding. Whether this is directly correlated with the general problem of pullet mortality in laying flocks or is related to the special conditions existing in feeding stations is not entirely clear.

The rapid growth of the commercial broiler business and some development in other phases of poultry-meat production suggest that more attention might well be given to research on factors affecting poultry-meat quality.

POULTRY-FARM MANAGEMENT

The poultry business, like nearly every other productive enterprise, passes through periods of relative prosperity and depression. There have been times when the margin between costs and income was so wide that nearly all persons engaged in the business were making money, and there have been other times when the major items of cost were so high in relation to the prices received for poultry and eggs that only the most efficient operators could make a profit.

Cost-account records and studies of poultry-farm organization have, however, brought out the significant fact that, except for temporary maladjustments in the price situation, the matter of a high or low labor income depends almost entirely on the poultryman himself. The possibilities seem to be limited largely by the extent to which he will adopt profitable practices and set up an efficient farm organization.

Research in farm-business analysis has made clear the economic importance of such factors as size of business, egg yield per hen, labor efficiency, farm layout, careful buying of feed, rigid culling, strict sanitation, and efficient marketing. It is no easy task to make a poultry-farm business pay, but research has provided the measures by which the weak spots in any such business can easily and quickly be determined if adequate records are kept by the operator.

With cost and income data available from studies made in many different localities, there is no need for anyone to begin a poultry enterprise without an adequate picture of the financial problems with which he will be confronted. This has been one of the intensely practical contributions of research to the poultry industry.

CONCLUSION

In this brief survey of research in poultry husbandry, only a few items in each of several fields could be given specific mention, but I think we are fully justified in concluding that without the facts which organized research has made available, the poultry industry would be years behind its present state of development. Many of the results have not yet found wide application, and some of them never will, but if no more than 5 or 10 percent of the research findings prove to be of real practical value to the industry the benefits will far outweigh the cost of the other 90 or 95 percent.

We have seen poultry research advance from the stage of simple tests of feeding and management practices to a point where some of the best-trained minds in genetics, biochemistry, physiology, endocrinology, and a dozen other related sciences are focusing their attention on the fowl and its products, both in the interest of the poultry industry and in an attempt to discover principles which may have a much wider application.

Those of us who make our living from poultry husbandry, whether by the production and marketing of eggs and poultry, or by one of the many lines of endeavor which depend on the basic fact that eggs and poultry are prized as human food, should be ever grateful to those early workers who showed the way to the exhaustive and fundamental research of the present day, and who helped to dignify the industry and the profession so as to insure the financial support which is needed to make such research possible.

We also have a responsibility to the next generation. More important than our interest in the hen and her products, more important than our enthusiasm for finding answers to new and intriguing questions which involve research in poultry husbandry, and more important than the answers themselves, is the contribution which we can make to better living for thousands of farm families, and especially for the boys and girls who will constitute the farm families of tomorrow.

A REVIEW OF THE ACCOMPLISHMENTS IN THE FIELD OF POULTRY PRODUCTS RESEARCH

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The agricultural world is just pulling away from an overpowering and almost exclusive desire to "make two blades of grass grow where only one has grown". It is now recognizing that the second blade may be useless, or worse than useless, unless it can be carried, in good condition and with profit, to the ultimate consumer. In other words, research for many years has been contributing to poultry husbandry, but serious investigations into the results of poultry husbandry—that is to eggs and poultry after they are produced, and what becomes of them—were few and far between until about thirty years ago. Since then the increasing economic importance of poultry products and the complexity of marketing problems has so stimulated research that a voluminous literature has already appeared and the current scientific journals of all sorts attest to the great variety of topics under investigation and the excellence of the material emanating from laboratories, packing houses, and marketing centers.

The importance of such knowledge, in its practical application to all phases of the industry is so great that I stand very humbly before you, feeling my inadequacy to perform the task assigned to me. To draw within the allotted period a picture of the problems pertaining to poultry products as illumined today by recent research; and to carry over into the fields now barren of facts those flashes of light which point the way to the solution of the problems of tomorrow is to be torn between the responsibility of the task and the honor of being selected to perform it. I beg your indulgence.

EGGS

It used to be that a market egg was "fresh" or "not fresh". Consumers in a few localities were interested in the color of the shell. Very rarely one heard comments on the color of the yolk. No one, unless he owned some laying hens, expected reliably good eggs in winter, and the price was very high. Consumption stepped up, and so did the quality, in the spring, but the heat of summer sent quality out of the window and again eggs were in consumer disfavor. Research gathered facts to assist in breeding for more eggs per hen, for incubation, rearing chicks, and such like production problems. About 35 years ago the edibility of eggs which had been held in cold storage came up for lively debate.

There began then a study of the chemistry, bacterial flora, and keeping-quality of eggs in market food channels which has continued ever since. As the value of the egg crop has increased, as the importance of eggs in the human diet has been disclosed, and as the national losses due to deterioration in quality between the producer and consumer have forced themselves upon our economic consciousness each part of the egg, from shell to latebra, has been the subject of research work. Let us look at these integral portions of the egg and the sort of information our studies have yielded.

Shell

We have some valuable information on the thickness of the shell produced by different breeds of hens and on different diets, especially in relation to calcium metabolism; and very important that is to egg marketing, as any shipper or receiver will tell you. There is a definite endeavor in the industry to produce uniformly efficient shells because poor shells account for financial losses. There is a growing literature on the histological structure and chemical composition of the shell with practical pointers all along the way to guide those who would know more about the effect of many or few pores, of large or of small pores, of the quantity of water in the shell, the relative proportions of organic and inorganic matter in their relation to stability of composition of the egg meat as it journeys from the hen to the consumer with all the vicissitudes of time and temperature it may have to survive.

There are studies, also, of the bacterial flora of the shell, and the organisms found upon it are as numerous and varied as the types found in air and water and soil and intestinal refuse. We have been shown how molds work their way through the larger pores and establish their mycelia on and then through the shell membranes and so into the egg meat. We have valuable information on the effect of dirt or water on the shell on the long time keeping quality of eggs in cold storage. The more information we get, the more respect we have for the part played by the shell in the market history of eggs, and there is still much information waiting for the research worker to dig out.

Membranes

We have information on the chemical composition of the two membranes within the shell. We need more research work on their functions, and the role they play in the career of the market egg. Casual observation shows that some eggs have thicker, tougher membranes than others. Some are almost colorless, some are tinted, especially with a pink color. That is objectionable when candling. There is a waiting field here for some research worker.

Egg white

The chemists studying proteins, long before the market egg was an object for research, used egg white as their type material for high grade albumins. Incidentally, they determined the gross composition of egg white. The egg candler learned to correlate appearance with condition of white with some success for market grading but fell far short of attaining the accuracy demanded by the scientist. Until about ten years ago there was a little factual knowledge of the part played by the white in the market egg and a vast number of opinions founded largely on wishful thinking, a condition leading to endless argument wherever two or three egg industry men were gathered together. Facts from research laboratories, scattered the width of this continent and from Europe as well, began to come in. Many of the old arguments ended; there are still many waiting to be ended.

One of the milestones along the road to knowledge of eggs was the finding of a bag of thick white containing thin white and the location and relation of the outer thin white and the very viscous layer clinging to the yolk. Impetus to the study of quality and stability of structure in the market egg was given by the development of methods for the quantitative and dimensional study of the thick and thin portions of the white—several methods each valiantly defended by its originator, and so leading to the accumulation of more knowledge.

Meanwhile, the chemists were again studying egg white,—this time to determine wherein were the basic differences to account for the visual differences; and so the mucin threads were found and the story of enzyme action in the reduction of thick to thin white was started—not told, just started—and surprises came along with the figures giving the distribution of the solids in thick and thin white.

Endless have been the arguments of laymen and scientists about the effect of the diet of the hen on the white of the egg. So, when five years ago or thereabouts, gossip came out of some laboratories that the condition of the white in a new laid egg was not due to feed nor to breed but to the inherited ability in certain families to produce eggs with thick whites and an inability in other families to do so, both factions took a long breath and in the ensuing arguing we have learned, and are learning, more about egg white than was in our wildest dreams ten years ago. We are still arguing, but, better than that, calm and dispassionate work in breeding pen and laboratory and feeding battery is being carried on. As in so many controversies, it would now appear that a modicum of truth pervades both their houses. The inheritance forces were earliest in the field. Their literature is the most voluminous. Those studying the effect of feed are slowly adding facts—not yet enough to do much more than again to light the fire of discussion, but inexpressably valuable in that they will act as stimuli in obtaining more and more knowledge to the ultimate advantage of all those interested in the science and the business of the market egg.

The chemists have determined the pH of the whole egg, of white, and of yolk. When the white ages the pH goes to the alkali side. The new laid egg contains carbon dioxide, as does the blood of the hen. When the carbon dioxide diffuses, the pH rises, liquefaction of the thick white is accelerated, the egg loses some of its pristine flavor and, to most people, is less palatable. By charging the atmosphere with an adequate amount of carbon dioxide, the pH of egg white is maintained at approximately 7.9 and the rate of deterioration is markedly slowed.

England and the Continent are using gas storage for eggs extensively. The United States has done but little commercially. It is possible that the method would have advantages in certain restricted fields of egg storage in the United States.

Yolk

Research has proven that the color of the yolk is entirely dependent upon the amount of xanthophillic acid compounds fed to the hen—in other words, upon the amount of green feed and yellow corn. Long, detailed, and most painstaking investigations have shown that the husbandman can furnish yolks of any depth of yellow desired. He can furnish red yolks if he feeds pimento peppers. Experimentally the investigator can produce eggs with yolks which are colorless or of a sickly gray—no one would wish them commercially.

Have we given the vitelline membrane the attention it deserves? I doubt it. Histologically we know its cellular structure. Its breaking strength has been measured as a means of determining deterioration. We may find interesting information if the influence of breeds, feeds, and inheritance factors on the vitelline membrane are studied.

The white layers of yolk were not supposed to play a role in market eggs until research indicated that the translucent areas frequently observed on the yolk and breaking the continuity of its glistening yellowness are due to an incomplete layer of either white or yellow yolk, so permitting the layer just below to be seen. Is the white yolk laid down at night, and the yellow yolk in the daytime? From very recent publications it appears that we need more information on this whole subject of white and yellow yolk and their deposition.

Most important, however, from the viewpoint of the market egg is the prevention of chick development. It is Mother Nature's concern that the egg produce a chick. Beyond that she is not interested. Those dealing with eggs as a food for man are concerned in preventing the egg from becoming a chick—so concerned that the flocks producing eggs for food are guiltless of cocks. True, research has fixed the temperature at which proliferation of the cells of the embryo may be expected and the engineer has constructed refrigerating facilities for the maintenance of temperatures below the danger line. But research has also shown—and experience has abundantly verified,—the rapidity with which those embryo cells divide once the temperature is favorable. Hence we find more and more flocks without male birds where eggs are a specialty, and greater and greater care on the part of the general farmer to isolate his pullets.

Thirty years ago such precautions were almost unheard of. Only by the reiterated findings in the research laboratory and continuous precept and example to the farmers have they been brought about. But let no one think the job is completed!

Chemically the yolk is remarkably stable—nature sees to that for the sake of the chick—and as a package of nutritive compounds it is hard to beat. The less stable white and the vitelline membrane in the infertile egg are the undoing of the yolk as the market man sees the problem. The loss of viscosity in the thick white permits the yolk to floate near the shell. The passage of water from white to yolk, in an endeavor to establish osmotic equilibrium, strains the vitelline membrane and what was a yellow sphere becomes a flattened disk. Laboratory work has shown a definite relation between the thickness and the diameter of the yolk—the "yolk index" as it is called, and the quality of the egg. The two indices—that of height of thick white to diameter and of width of yolk to height—are invaluable in judging deterioration in the opened egg with which we endeavor to correlate the appearance of the egg before the candle.

Consumer acceptance

The consumer is the judge and the jury. What the consumer accepts, prefers, and will pay for, is to be provided by the egg industry regardless of all else. True, the consumer can be and is being educated to exert an intelligent preference and, right here, we should pay our respects to the pioneer work going on in the education of the public in matters relating to poultry products. Without such work the chances for the utilization by the industry of many of the scientific facts would be gray, indeed. Such educational work should be encouraged by all means.

Consumer acceptance involves an accurate and reliable separation of market receipts into *grades which have significance to the consumer*. The consumer sees an egg out of the shell, or as cooked in the shell. The consumer does not see the egg before the candle. Research has given invaluable assistance in the making, by means of candling, of grades of eggs which do have a definite value to the consumer. Research has unearthed, also, facts regarding the individual eggs which are invaluable to the industry at large and to the army of serious men working to improve it. Not all of these facts are pertinent to making grades of market eggs which have preference differences to the consumer. We now need research to determine, from the practical side of the market man and his customer, the relative importance of the things we see before the candle, or what we *think* we see. That is a field in which scientists, Government officials, the industry and the consumers must cooperate. Until they do, no one can fully benefit from the researches finished and in progress or planned. They are buried in the dark of library shelves instead of shining forth from the counters of the retail stores.

Frozen eggs

This is a great industry, soon to encircle the world, because egg breaking is progressing in Central Europe as well as in China and the United States. It is an example of how scientific research, accepted and utilized by a troubled and discredited industry, can lead to one which is profitable, respected, and economically sound. Research, conducted cooperatively and with a definite goal in mind, by chemists, bacteriologists, and refrigerating engineers is directly responsible for the frozen egg industry today.

Publications in scientific journals setting forth the knowledge obtained are not as numerous as we would like to see them. We do have papers on the chemical composition of whites, yolks, and whole eggs, on the bacterial flora of frozen egg, on the physical changes which egg undergoes to make it more and more viscous as the holding period in the freezer lengthens, and we have an enormous amount of information if we pick and choose from the statements made to the patent office and from which patent rights have been granted.

Dried egg

Commercial research is almost entirely responsible for the development and utilization of data on which to manufacture an acceptable dried egg. It is recorded almost entirely in the Patent Office.

The dried egg white from China, naturally fermented, has been studied and an artificial fermentation reported on, as well as a thinning of the white by means of enzyme action and by strong acids, such as sulphuric. China has been the great producer of dried egg. With altered conditions in the Orient, the United States is now developing a dried egg industry. We may, therefore, expect additions from the scientific research workers to our knowledge of the subject.

The nutritive value of eggs

How do we stand on our knowledge of the end and aim of the market egg, the nourishment of man? Not so badly as some suppose though the field for further researches is enormous.

As the chemists studied egg albumen as a prototype of proteins, so have physiologists used egg white in studies on digestion of proteins, beginning as far back as 1833 when Beaumont fed Alexis St. Martin.

Studies on vitamins in eggs, notably A, D, and G, have put eggs as foods in a class by themselves. Phosphorized fats in egg yolk and yolk proteins are outstanding in food value.

Studies on the mineral content of eggs have been made and feeding experiments to show the availability of the iron in the yolk with and without the addition of copper. Recently there has been published a critical review of investigations on the nutritive value of eggs, which is a mine of information as well as a stimulus to further research.[1]

Preservation of eggs

For years the preservation of eggs has been associated with "cold storage", and research work pertained to the behavior of eggs under refrigeration for seasonal periods. Temperature, humidity, the physical condition of the shell and the interior were all taken into account. Recently the field has been widened in that we are studying the effects of various production factors on the stability of the composition and structure of the egg. We are learning, also, something of the effect of inheritance factors, such as thick white, on the keeping quality of the market egg. In the past we have done much to learn about the physical conditions prevailing in the warehouse and their effect on quality. Now we are giving, as we should, more attention to the egg going into the warehouse and how eggs from hens of certain strains or on certain diets will behave when refrigerated for several months. This is a promising and important field for research. It is likely to solve many a controversial question and to point the way to the reduction of many a financial loss. Most important of all we are likely to learn how we may maintain consumer acceptance during the season of egg scarcity.

POULTRY

When the bird leaves the farm to become food for man, we absolve the poultry husbandman from further responsibility. It now becomes the ward of the manufacturing, marketing section of the industry and the research work assumes an entirely different character. To be sure, the packer and the distributor are distinctly limited in their field of operation by the kind of chicken which the farm sends to them. Most often the packer must supplement the farm feeding, if well fatted, tender meat is to be produced. This holds true for even the broilers and fryers grown in the specialized "broiler factories", as they are called, now prevalent on the Eastern Seaboard and appearing in certain localized areas in the Midwest.

Fleshing

The commercial fleshing of poultry in feeding stations is an enormous industry and as such has commanded the attention of scientific workers for many years. Feeds, breeds, length of feeding period, age in relation to gains in weight, air conditioning of feeding stations and a host of other pertinent subjects are treated of in the literature. Yet the effect on the practices of the industry is peculiarly small. Each packer's feeding station is handled as its owner deems most profitable to his business. Two packers in the same town, drawing supplies from the same territory, will operate their feeding stations quite differently.

Obviously, there is much to be learned about feeding poultry to manufacture flesh for food purposes. And, obviously, the packer should know the main issues to which the poultry producer is devoting himself in order to improve his birds. Vigor is one of the most important subjects now under investigation. The cry of the packer is that he cannot feed the birds in his feeding station for more than a few days, whereas 20 years ago the birds ate and thrived and grew soft meated for two weeks or more. Why? We are still awaiting a satisfactory, comprehensive answer.

The current literature is full of excellent fundamental studies of the part played in nutrition by various chemical compounds—vitamins, hormones and minerals. As yet these basic facts have not been correlated and applied to the problem of commercial fleshing, but it would seem that the time is almost ripe to do so. We have, also, many isolated rather short studies of one or another subject connected with fleshing, frequently applying to a local problem or to some special condition. Again there is the task of comparing, correlating and evaluating this rapidly growing literature.

Economic conditions stimulate the strains and the breeds which develop the greatest amount of meat in the shortest time, and breeders are doing some good work along that line. Demand for quality as well as economics points to studies, again genetic, to provide body shape acceptable as meat birds and such investigations have been published, while additional studies are in the offing.

The effect of various grains when fed singly or in mixtures, corn often being the basic grain, has been the subject of research for years, yet the topic is not exhausted and some recent work is very valuable. We have studies on supplementing the cereal foods with the various vitamins and hormones, especially cod-liver or other fish oils carrying vitamins A and D. A great field awaits someone! Indeed, with our newer knowledge of the composition of proteins and especially of supplementary foods and our growing knowledge of substances stimulating growth in size, it would seem that we stand upon the borders of a new era in fleshing breeds and strains of poultry adapted to that specific purpose.

[1] A review of investigations on the nutritive value of eggs, MARY SWARTZ ROSE and ELLA MCCOLLUM VAHLTEICH. Journ. Am. Diet. Ass'n., Vol. 14, No. 8. October 1938.

Killing, bleeding and defeathering

About 30 years ago when, under Government auspices, a pamphlet was issued giving information on the bony anatomy of the chicken's head and its blood vessels, with instructions on bleeding and defeathering, there were some patronizing smiles within the group of "pure scientists". Little did anyone then know of the field awaiting investigation! Of scalding versus dry picking, and their effect on keeping quality. Of wax as a defeathering agent. Of a dip in moderately hot water to assist in picking and, last but not least, of the use of the electric current to kill poultry. Indeed, the field is still largely open. We speak of "well bled" and of "poorly bled" birds, but we have no quantitative criteria by which to gauge success in removing blood from the carcass. We know by visual observation when the feathers are removed but we have no accurate knowledge of what has happened to the feather follicle during the process. We do know that scalding lowers the keeping quality and renders the birds more susceptible to freezer burn. We do not know why. We have some evidence indicating an effect on the skin and on the fatty layer under the skin of defeathering by the "semi-scald" method, in which the bird is plunged into water at about 126° F. for 20 or more seconds. We do not have comprehensive information and, considering the enormous volume of poultry so defeathered, it is very desirable that a careful study embodying the bacterial, histological and chemical history be made of this process. The same may be said from the viewpoint of scientific basic facts of the wax method of defeathering, which has been so well worked out from the commercial side for adaptability and practicality. We must never lose sight of the extreme delicacy of the layer of fat below the skin, nor of the very specialized structure of the skin itself to perform protective functions.

Indeed, the entire field of killing, bleeding, and defeathering is almost barren of facts based on research employing up-to-date laboratory methods. Some results have just been published on killing by means of an electric current which may, and we hope will, act as a stimulus to other investigators to pursue the subject into the many avenues on which it touches.

Removal of animal heat

But little has been done from the scientific aspect of this subject since the Government bulletins dealing with the preservation of poultry flesh were issued more than 20 years ago. Poultry packers have improved the facilities for cooling from an engineering standpoint. Individually, they have acquired a great amount of practical experience in the adjustment of temperatures, humidity, air circulation, and speed of cooling. But a critical, constructive, exploratory study looking backward to the methods of feeding, killing, and defeathering, and forward to the marketing routine, has still to be made. No packer of experience will question the importance of such a study.

The poultry industry of the Midwest, in the interest of minimizing deterioration and preventing the enormous food and money losses which followed the shipping of poultry ice packed to the Eastern Seaboard, adopted almost exclusively cold air as a means of removing animal heat. For more than 15 years the great bulk of the tonnage of dressed poultry from the Midwest has moved dry packed. Studies under Government auspices of the comparative rate of deterioration in wet packed versus dry packed birds showed an increased rate of multiplication of bacteria in the flesh and an increased rate of chemical decomposition of fats and proteins in the wet as compared with the dry packed, when the results were calculated on a basis adjusted to the amount of water absorbed by the carcass of the wet packed bird and the loss of soluble proteins which are leached out.

During the past five years a very large production of poultry has sprung up on the Eastern Seaboard. These birds, originally marketed alive, are now too numerous to be limited to that trade. Many being dressed for market are cooled and shipped in water and fine ice. Market gluts are forcing freezing and holding in freezer storage. So far there has been no authoritative, impartial investigation of the effect upon the edible quality, the chemical composition, and the perishability of birds so bred, raised, and cooled. It is eminently desirable that such a study be made. Practical observations indicate an extreme delicacy of structure which increases the difficulties attendant upon dressing for market and holding in freezer storage.

Freezing

The greatest hazard which dressed poultry faces is its extreme perishability. Therefore, the task of finding ways which will reduce perishability to a minimum. Sterilizing the flesh by heat—canning, as we call the commercial application of sterilizing by heat—is the most efficient, but the field for the utilization of canned chicken is limited. Hard freezing comes next, and since this practice is the best way we, at present, have of preserving the original composition of the bird, it is the most popular.

Ever since the start of this practice the temperatures used have been slipping down. Twenty-five years ago 10° F. was in common use. Then the industry used 5° F., and now we speak casually of −25° to −50° F.

Researches under Government auspices were the most prolific sources of information in the early days of frozen dressed poultry, though chemists in certain industrial laboratories made valuable contributions to our knowledge of the effect of low temperatures on bacterial proliferation, cellular structure, and the denaturing of proteins. About the time of a resumption after the war of peace-time research came some accurate data on what was termed "quick freezing", that is, passing through the zone of the freezing out of water in the shortest practical time. Applied first to fish its beneficial effects were unassailable. The consumer accepted fish so frozen. The problem was intriguing to engineers, physicists, chemists and bacteriologists. Investigations got underway in many laboratories in record-breaking time. The fact that fruits and vegetables could be preserved by this method in a condition acceptable to the consumer brought horticulturists, plant physiologists and pathologists, and a quite different group of chemists and fungologists into the picture. There has resulted an extensive literature of exceptionally high grade work, and the papers are still coming.

Upon poultry, as such, there has been but little done. Upon meats, in general, much more has been done. Up to a certain point we may accept the basic facts of meat freezing as applicable to poultry. For the facts pertaining strictly to poultry flesh, we look for clarification to the results of studies now underway.

One of the unsettled and very important questions is to how low a temperature we can subject poultry flesh without so denaturing the proteins that they will not again unite with the water frozen out of them. We know from reliable studies that in beef 71.3 percent of the water present is frozen at 21° F. and 100 percent is frozen at −67° F. We know, also, that when the "bound water", so called, is frozen the protein does not completely reconstitute on thawing. While we do not now have exact data on the "bound water" in poultry flesh we have enough information to conclude that −30° F. is a safe lower limit and that the range of −20° to −30° F. is commercially satisfactory according to present market requirements. Below −40° F. we may find it difficult to reconstitute on thawing.

The term "quick freezing" is being loosely used. Strictly, and as used in the scientific literature, it requires that the "zone of maximum crystal formation", which means solidification, be passed through in 30 minutes or less. The temperature ranges from 31° to 25° F. As we have seen, only about three-fourths of the water present is frozen within the above temperature range and we must drop to well below zero if we are to obtain a proper balance between water crystals and bound water.

Commercially we are more apt to employ a lower "sharp freeze", that is a temperature in still air of −10° to −15° F., with poultry in packages of such thickness that from 6 to 24 hours are required to freeze solidly. While such a practice is superior to freezing at 0° F. or somewhat above, the maintenance of the integrity of the cytological structure is not the same as in true "quick freezing".

The problem is not only the initial formation of small crystals. One must keep them small. Research has shown that storage at temperatures below 0° F. is necessary if the growth of crystals is to be prevented. The indications are that the water freezing out at the lower temperatures melts and so adds to the size of the crystals formed at higher temperatures. The same thing happens when the storage temperatures fluctuate and the higher the temperature of the storage room, the greater the effect.

Dehydration during storage has come in for considerable study, but more is needed. We know that "freezer burn" is due to desiccation of the skin and of the underlying tissues. It interferes with the good appearance of the birds and according to one investigator who has studied fish especially, it interferes with flavor. "Pockmarking", which is due to the drying out of the tissue around the feather may, according to certain research, be closely associated with the disturbance during defeathering of the fatty layer just under the skin. If so, we have an additional reason for a closer study of the results of our various methods of removing the feathers.

Since freezer burn is dehydration, obviously there is a point where water vapor in the air of the storage room will be in equilibrium with the vapor pressure of the flesh and there will be no evaporation. Some very valuable basic information has been obtained which shows that the lower the humidity in the storage room, the sooner surface drying appears and the more extensive it becomes as time goes on. For instance, at a relative humidity of 80 and a temperature of −7° F., freezer burn appeared in 11 weeks, and after a storage period of 30 weeks, 5–10 percent of the skin area was affected. The same relative humidity, 80 percent, at +7.5° F. gave 20–25 percent of the skin area affected after 83 weeks. However, there was no freezer burn at either temperature when the relative humidity was 95 percent and very little when the humidity was 90 percent.

It is possible to raise the humidity in freezers either by reducing the temperature or by introducing water vapor, since there is a slow but definite evaporation of ice crystals. More study is needed on this whole subject of freezer burn versus temperature and humidity. It would seem, since this is admittedly the age of the package, that concentrated efforts in this field should bring valuable results.

Eviscerated poultry

On the subject of eviscerated poultry we can touch but gently until research enlightens us further. Most of the literature at present deals with the opinions of the writers rather than hard facts and the acceptance or nonacceptance by the distributing trade and by the ultimate consumer.

Some cooking tests made upon birds, drawn and undrawn, put through a routine approximating good market handling gave results in favor of the drawn birds. Such findings, however, must be supplemented by studies of birds actually on markets at different times in the year and with birds of different ages and where sale and consumption is prompt and where it is not prompt.

There should also be similar studies made on birds in the round where the time elapsing since the last feeding has permitted the gut to be fairly well emptied, as compared with the present practice of killing while the gut is normally full or even plugged in order to increase the apparent gains in the feeding batteries and the ultimate weight in the round after the bird is killed and picked. Studies under Government auspices, unfortunately never published, indicated damage to keeping quality and to flavor by killing when the bird is in feed, and research later in England stresses the need for adequate emptying of the gut before killing if stability of quality is to be conserved.

Economically, much is to be said in favor of drawn poultry. There would be a saving of about 25 percent in the tonnage shipped. The offal could be made into fertilizer. Possibly, the glands now discarded could be used as a source of therapeutic agents, but their size is so minute that unusual qualities would be necessary to make utilization practical.

There is a preconceived idea that the birds should be drawn before the removal of animal heat and the carcasses quick frozen at once. Sober science neatly disposes of such psychology by showing that if quick freezing is to perform its proper functions, especially in connection with the "weeping" or "dripping" of the flesh on thawing, the birds should hang for twenty-four hours at 32–34° F. before freezing. If frozen while warm there is no advantage in quick freezing. We do not know the mechanism of these postmortem changes in muscle, but research now underway on poultry and what has been done on beef, mutton, and pork, indicate a tendering process as well as certain changes in flavor and a coagulation of muscle protein which may have a deeper significance than we are now aware of.

Transportation

Just as temperatures in the freezer storage have gone lower and lower, so are we pushing down temperatures in refrigerator cars. From time to time the railways offer an improved car to Government agencies to be studied and the results are generally encouraging.

Ice, or ice and salt, is still the preferred refrigerant. Heavier insulation, that is up to six inches of corkboard, has been relied upon to prevent thawing of frozen products.

Mechanical devices with moving parts are not, so far, sufficiently foolproof to be trusted in a refrigerator car. But now there is under development a car cooled indirectly by solid carbon dioxide, in which the temperature can range from 40–50° to 0° F. and which bids fair to be practical from both economy and efficiency viewpoints. We should watch the journals of refrigerating engineering for further reports on the progress of this device.

SUMMARY

In spite of the relatively short period during which poultry products have been considered objects for scientific research, an extensive literature has developed in the fields of genetics, chemistry, physics, bacteriology, and nutrition. Even so, as one critically considers the problems facing the industry in the marketing and the preparing for market of poultry products, the empty spaces in our field seem larger than those covered or even partly covered by scientific facts.

Yet we have a sprinkling of endeavor here and there over a territory so wide that we cannot hope ever to exhaust it and so fundamentally important to agriculture that no commonwealth could permit interest to lapse. At long last, the poultry industry exists because eggs, like milk, are a unique food for which there is no substitute; and poultry flesh can be produced so quickly and so easily as compared with cattle and even with hogs, that it, like fish, is an economic insurance against a shortage of meat proteins.

To hit the highlights of scientific research in the field of poultry products as we have tried to do in this brief survey of the subject, leaves one out of breath, but keenly alive to the fact that here is a great—a very great—opportunity for those trained in widely separated scientific fields to explore cooperatively territories new and rich beyond expression, not only in scientific facts but in the application of those facts to the betterment of modern living.

SPECIAL SESSIONS

SECTION 1. GENETICS AND PHYSIOLOGY

CONTRIBUTIONS OF GENETICS TO PRACTICES IN POULTRY BREEDING

By D. C. Warren, *Professor of Poultry Husbandry, Kansas State College, Manhattan, Kansas, U. S. A.*

Owing to its inherent limitations, the science of genetics frequently has been disappointing to the practical breeder in failing to provide an immediate solution to his many problems. The characteristics of the fowl, such as fecundity, rate of growth, body size, and egg size, which have greatest economic significance, have usually been of a strictly physiological nature. Such characteristics, which have been somewhat unyielding in the hands of the breeder of poultry, have been perplexing to the geneticist also in his attempt to analyze their genetic make-up. The complicated genetic constitution of these characteristics and their susceptibility to the influence of the environment have retarded progress in constructive breeding and complicated the genetic analysis.

It is probably true that the greatest contribution of genetics to poultry breeding has been the development of a new technique of attack. The initiation of the practice of this technique was the reason for Mendel's success, whereas his predecessors had repeatedly failed in the recognition of the laws of inheritance. Mendel's contribution was the focusing of attention on the results of single-pair matings as a unit, rather than on massed results. Mendelian technique when applied to practical breeding problems is progeny testing. In the progeny test, the estimation of a breeding animal's value is based on the qualities and performance of its offspring. From a genetic viewpoint, it is a method of estimating the relative inherent make-up of the parents by the appearance of desirable and undesirable characteristics in their offspring.

Because of the large numbers of individuals which may be used in the operations, the fowl is better adapted to the use of the progeny test in constructive breeding than any other domestic animal. The successful early poultry breeders probably utilized the progeny test to a greater degree than they realized. It is only in recent years that large numbers of practical breeders have recognized the possibilities of systematic application of the progeny test for the fixation of the desirable characteristics in the fowl, and the elimination of the undesirable ones. With the more general adoption of this technique of breeding, a great stimulus to poultry improvement may be anticipated.

Because of the paucity of workers and the rather extensive facilities needed for such investigations, advance in the field of poultry genetics has been rather slow. However, the work is gaining momentum each year. The application of the knowledge of sex-linkage to the problem of sex recognition at hatching, the possibilities of breeding for disease control, and the utilization of genetics in solving the problem of broiler feathering are instances in which the geneticist has made, or shows promise of making, contributions of immediate economic importance.

DIE ERBLICHKEIT DER BRUSTBEINVERKRÜMMUNGEN BEIM HUHN

Von P. Carstens *und* J. Prüfer, *Aus dem Institut für Tierzuchtlehre der Landw. Hochschule Hohenheim, Deutschland; Direktor: Prof. Dr. Carstens*

Im Verlauf der planmäßigen züchterischen Bearbeitung unserer Geflügelbestände konnte eine große Anzahl von Anomalien nachgewiesen werden, denen zum Teil Erbfaktoren, zum Teil andere Ursachen, Umweltseinflüsse usw. zugrunde liegen. Die Schäden, die dadurch unserer landwirtschaftlichen Wirtschaftsgeflügelhaltung entstehen, sind naturgemäß außerordentlich verschieden. Es ist eine lange Reihe, die sich uns aufzeigt, angefangen bei den Anomalien, welche die Leistungsfähigkeit unserer Bestände überhaupt nicht oder nur wenig beeinträchtigen, über die schweren Leistungsschäden bis endlich zu den absoluten Letalfaktoren. Es ist daher auch durchaus verständlich, daß die angewandte Genetik diesen Problemen ihre besondere Aufmerksamkeit schenkte. Die Beschäftigung mit diesen Fragen geschah nun aber durchaus nicht allein aus der Freude heraus, den Erbgang des einen oder anderen interessanten erblichen Merkmals durch eine Faktorenanalyse klarzulegen, sondern vor allem auch mit dem Bestreben, die züchterische Praxis von leistungsmindernden Faktoren zu säubern bzw. sie vor der weiteren Ausbreitung bestimmter zuchtschädigender Faktoren zu bewahren. Zu einer solchen Anomalie schlechthin werden nun auch die Verkrümmungen des Brustbeins bei unseren Hühnern gerechnet.

Bei Einrichtung des Reichsherdbuches wurde diese Mißbildung des Brustbeins auf alle Fälle für so nachteilig angesehen, daß Hähne mit verkrümmten Brustbeinen nicht angekört werden durften und demnach auch in der Zucht keine Verwendung finden konnten. Da man zu diesem Zeitpunkt jedoch weder sichere und ausreichende Unterlagen über die Stärke der Ausbreitung dieser Anomalie in unseren Beständen zur Verfügung hatte, noch Ergebnisse über die Beziehungen zwischen den vielseitigen Leistungen unserer Hühner und dieser Mißbildung vorlagen, mußten exakte Experimente in Angriff genommen werden, um die einzelnen hier aufgeworfenen Fragen eindeutig und klar beantworten zu können.

In großangelegten Versuchen wurden zunächst in mehreren Untersuchungen die Beziehungen klar gelegt, die zwischen Verkrümmung, Umwelt, Legeleistung Fruchtbarkeit usw. bestehen. An einem Material von rund 2 800 weißen Leghorn und rebhuhnfarbigen Italienern sind wir nach $3\frac{1}{2}$ jähriger Arbeit dabei zu folgenden Ergebnissen gekommen[1 2 3]:

1.—Die Brustbeinverkrümmung tritt zwar am häufigsten bei jungen Hühnern, also während der Jugendentwicklung auf, befällt aber auch noch ältere, ja drei- und vierjährige Tiere. Sie ist also an kein bestimmtes Alter gebunden.

2.—Die Sitzstangen üben eine stark begünstigende Wirkung im Auftreten der Verkrümmungen aus.

3.—Die Verkrümmungen beeinträchtigen die für uns ausschlaggebenden Leistungseigenschaften der Hühner (Legeleistung, Fleischleistung, Gesundheit, Langlebigkeit, Dauerleistung, Befruchtung, Schlupf- und Aufzuchtergebnisse) in keiner Weise. Sie sind demnach nur als Anomalie, nicht aber als Konstitutionsschwäche zu werten.

[1] CARSTENS, WENZLER und PRÜFER: Untersuchungen über die Verkrümmungen des Brustbeins beim Huhn. Archiv f. Geflügelkunde, 10, 4/5. 1936.

[2] BIEGERT, HANS: Untersuchungen über Brustbeinverkrümmungen bei weißen Leghorn und rebhuhnfarbigen Italienern. Diss. Hohenheim. 1936.

[3] CARSTENS und PRÜFER: Abschließende Untersuchungen über die Verkrümmungen des Brustbeins beim Huhn, insbesondere die experimentelle Erforschung ihrer Erblichkeit. Archiv f. Geflügelkunde, 12, 3. 1938.

Die letzte und endscheidendste Frage: "Handelt es sich bei den Verkrümmungen um ein erbliches Merkmal?", konnte natürlich nur durch den Vererbungsversuch beantwortet werden. Über das Ergebnis dieser experimentellen Untersuchungen soll nun im folgenden näher berichtet werden.

Im Zuchtjahr 1937 wurden 2 Leghornzuchtstämme zu je 14 Tieren wie folgt zusammengestellt:

Stamm L 8

7 Hennen mit geradem Brustbein ø Eierleistung im 1. Legejahr 242,3 7 Hennen mit sehr stark verkrümmtem Brustbein ø Eierleistung im 1. Legejahr 239,7	×	Hahn mit tadellos geradem Brustbein

Stamm L 9

7 Hennen mit geradem Brustbein ø Eierleistung im 1. Legejahr 239,6 7 Hennen mit stark verkrümmtem Brustbein ø Eierleistung im 1. Legejahr 237,9	×	Hahn mit sehr stark verkrümmtem Brustbein

Tabelle 1 gibt Aufschluß über die Brutergebnisse der beiden Stämme wie auch der verschiedenen Gruppen innerhalb derselben.

TABELLE 1.—*Die Brutergebnisse der Versuchsstämme*

	Eier eingelegt	Küken	Befruchtung	Schlupf der Einlage	Schlupf der Befruchteten
			Prozent	*Prozent*	*Prozent*
Stamm L 8	503	349	96,0	69,4	72,3
Stamm L 9	559	427	95,2	76,4	80,3
gerade x gerade (L 8)	263	188	98,1	71,5	72,9
gerade x krumm (L 8)	240	161	93,8	67,1	71,6
krumm x gerade (L 9)	263	210	95,8	79,8	83,3
gerade x krumm (L 8 + L 9)	503	371	94,8	73,8	77,8
krumm x krumm (L 9)	296	217	94,6	73,3	77,5

Wie aus der Tabelle zu ersehen ist, sind die Brutergebnisse bei L 9, dessen Hahn ein sehr krummes Brustbein hatte, sogar besser als bei L 8, und die Paarung "krumm x krumm" hatte ebenfalls bessere Brutresultate als die Paarung "gerade x gerade". Der Aufzuchtverlust betrug bei L 8 4,0 Prozent, bei L 9 5,8 Prozent, einschließlich der abhanden gekommenen Küken. Ein auf alle diese Leistungseigenschaften irgendwie nachteilig einwirkender Einfluß der Brustbeinverkrümmung konnte also abermals nicht festgestellt werden.

Die weibliche Nachkommenschaft aus diesen beiden Stämmen wurde nun unter vollständig gleichen Verhältnissen zusamen mit den übrigen Junghennen der restlichen Zuchtstämme aufgezogen. Alle Tiere erhielten die gleiche Fütterung, Wartung und Pflege, sie wurden mit ca. 6-7

Wochen, je nach Schlupfzeit und Witterung, der Wärmequelle entwöhnt und kamen auf das Aufzuchtgelände in die hier gebräuchlichen Hütten, die sämtlich mit Sitzstangen ausgestattet waren, wie es der in der Praxis üblichen Haltungsweise entspricht. Im Alter von 26 Wochen, wo nach unseren früheren Untersuchungen der Höhepunkt der Verkrümmungen im Verlauf der Jugendentwicklung erreicht ist, wurden die einzelnen Bruten der Reihe nach, sowie sie in dieses Alter kamen, sehr genau auf ihre Brustbeinbeschaffenheit untersucht, und zwar sämtliche Leghornjunghennen des Jahres 1937, im ganzen 1130 Stück. Später wurde dann bei jeder Henne an Hand der Aufzuchtlisten die Zugehörigkeit zu ihrem Stamm festgestellt, und auf diese Weise die Nachkommen der Versuchsstämme L 8 und L 9 herausgezogen. Bei der Untersuchung der Hennen wußten wir also nicht, aus welchem Stamm die Hennen waren, die wir gerade in Händen hielten. Dadurch war jede auch unbewußte Beeinflussung des Urteils, jeder noch so stille Gedanke "Hier müßte doch etwas zu finden sein" vollständig ausgeschaltet.

Hähne wurden nicht berücksichtigt, da die Versuchsstämme keine Herdbuchstämme waren. Es wäre wirtschaftlich nicht tragbar gewesen, die aus diesen Stämmen anfallenden Hähnchen, also Schlachtware, ein halbes Jahr lang zu behalten, um dann die Untersuchungen vornehmen zu können. Es war aber auch nicht nötig, die Hähne mit einzubeziehen, da Hennen an sich ein geeigneteres Material darstellen und aus den beiden Versuchsstämmen insgesamt 309 Junghennen untersucht werden konnten (144 aus L 8, 165 aus L 9). Die restlichen 821 Junghennen (1130 minus 309) verteilten sich auf die übrigen 7 Leghorn-Einzelzuchtstämme:

TABELLE 2.—*Brustbeinbeschaffenheit der Leghornjunghennen 1937*

	gerade	leicht verkrümmt	stark verkrümmt
	Prozent	*Prozent*	*Prozent*
821 Junghennen aus Nichtversuchsstämmen	59,3	32,8	7,9
L 8 (144 Tiere)	60,4	38,9	0,7
L 9 (165 Tiere)	48,5	30,9	20,6
gerade x gerade (L 8, 76 Tiere)	63,2	35,5	1,3
gerade x krumm (L 8, 68 Tiere)	57,4	42,6	....
krumm x gerade (L 9, 84 Tiere)	57,1	27,4	15,5
gerake x krumm (L 8 + L 9, 152 Tiere ......)	57,2	34,2	8,6
krumm x krumm (L 9, 81 Tiere)	39,5	34,6	25,9

In Tabelle 2 sind die Ergebnisse der Brustbeinuntersuchungen der 1937er Leghornjunghennen niedergelegt. Es geht aus ihr zunächst hervor, daß der Versuchsstamm L 8 dem Durchschnitt der übrigen, nicht versuchsmäßig gezüchteten Junghennen recht nahe kommt. Er hat mit rund 60 Prozent den gleichen Hundertsatz an Tieren mit geradem Brustbein und weicht nur darin ab, daß er einen verschwindend kleinen Anteil an schweren Fällen (1 Tier unter 144 Nachkommen) und dafür etwas mehr leichte Fälle hat. Demgegenüber hat der Hahn des Stammes L 9, ein Bild robuster Kraft mit einem Gewicht von 2750 g, einen sehr schlechten Einfluß auf die Brustbeinbeschaffenheit seiner Nachkommen ausgeübt. Ein Anteil von 20,6 Prozent schwerer Verkrümmungen übersteigt ja nicht nur den des Stammes L 8, sondern auch den bei den übrigen Leghornjunghennen so erheblich, daß man ihn einfach nicht als zufallsbedingt ansehen kann. Wie groß der Einfluß des Hahnes ist, geht schon bei einem Vergleich der Paarung "krumm x gerade" in L 9 mit der Paarung "gerade x krumm" in L 8 hervor. Sie hätten ja theoretisch die gleichen Ergebnisse bringen müssen. Tatsächlich ist auch der Anteil an Nachkommen mit geradem Brustbein derselbe, der Anteil an schweren Fällen dagegen bei L 9 schon hier so gewaltig, daß er den Hahn stark belastet. Von seinen Nachkommen aus den Hennen mit krummem Brustbein weist dann ein Viertel starke Verkrümmungen auf, und der Anteil an Tieren mit geradem Brustbein ist auf 39,5 Prozent heruntergegangen. Es ist dabei garnicht

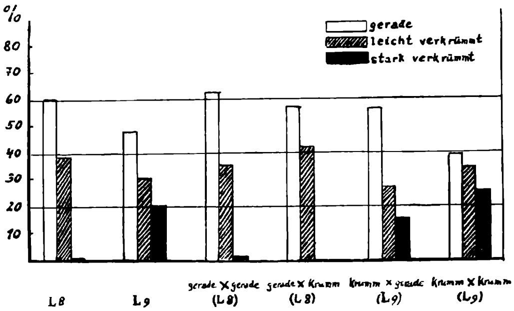

ABBILDUNG 1.—Brustbeinbeschaffenheit der Junghennen aus den Versuchsstämmen L 8 und L 9.

abzusehen, wie sehr sich das Bild noch im Laufe der Zeit nach der ungünstigen Seite verschieben wird, und man geht wohl nicht fehl in der Annahme, daß mit zunehmendem Alter nur wenige Nachkommen des Stammes L 9, deren Brustbeinbeschaffenheit bis jetzt noch normal ist, das gerade Brustbein behalten werden. In Abbildung 1 sind die Ergebnisse noch einmal in graphischer Darstellung wiedergegeben.

Wie aus der Tabelle 2 weiter hervorgeht, ergab die Paarung "gerade x gerade" zu 63,2 Prozent Tiere mit geradem, 35,5 mit leicht verkrümmten und noch 1,3 Prozent mit stark verkrümmten Brustbeinen. Diese Tatsache läßt darauf schließen, daß man nicht ohne weiteres von der Brustbeinbeschaffenheit der Eltern auf die der Nachkommen schließen kann. Neben der erblichen Disposition für diese Anlage spielen demnach auch noch Umweltsfaktoren für die Ausbildung dieses Merkmals eine wesentliche Rolle. Auch bei der Zusammenstellung von Zuchttieren mit vollständig korrektem Brustbein wird sich in der Nachkommenschaft stets ein erheblicher

Prozentsatz mit Verkrümmungen nachweisen lassen, wenn auch natürlich lange nicht in dem Maße, wie bei den Paarungen "krumm x gerade" oder "krumm x krumm". Auf Grund dieser Ergebnisse kommen wir zu der Schlußfolgerung, daß dieser Anomalie nicht unmittelbar ein "Faktor für Verkrümmung" zugrunde liegt, sondern daß es sich bei diesem Merkmal höchstwahrscheinlich um eine Anlage handelt, die die Kalkausnützung im Tierkörper maßgeblich beeinflußt und somit mittelbar die Verkrümmung hervorruft.

ZUSAMMENFASSUNG

Zusammenfassend kommen wir auf Grund der vorliegenden experimentellen Untersuchung über die Frage der Erblichkeit der Brustbeinverkrümmung zu folgendem Ergebnis:

Die Erblichkeit dieser Anomalie ist als erwiesen anzusehen, jedoch mit der Einschränkung, daß es sich wahrscheinlich um eine Disposition für die verringerte Fähigkeit, den Kalk der Nahrung zum Aufbau eines festen Knochengerüstes auszunutzen, handelt. Trotz Vorhandenseins der Anlage braucht also unter besonderen Umständen dieses Merkmal phänotypisch nicht unbedingt in Erscheinung zu treten. Ein Entzug der wohl allgemein üblichen Sitzstangen und dadurch bewirkte geringere äußere Beanspruchung des Brustbeins kann schon das Auftreten der Verkrümmung sehr stark hemmen.

Aus diesem Grunde, eben durch die starke Abhängigkeit der phänotypischen Äußerung dieses Merkmals von der Umwelt, wird auch eine Einzelanalyse nur schwer zu einer faktoriellen Auslegung dieses Falles führen können. Wenn somit die Frage, ob es sich um einen dominanten onder rezessiven Faktor handelt, auch vorläufig offen bleibt, so ist jedoch das durch die vorliegende massenstatistische Auswertung gewonnene Bild so eindeutig, daß die Annahme einer Erblichkeit dieses Merkmals durchaus gesichert ist.

Die früheren und auch jetzigen Untersuchungen haben den Nachweis erbracht, daß es sich bei der Brustbeinverkrümmung um eine Anomalie, einen Schönheitsfehler, und nicht um eine leistungshemmende Eigenschaft handelt, sodaß ihr in der Leistungsgeflügelzucht keine übertriebene Beachtung zu schenken ist.

SUMMARY

In summarizing the above experimental results on the question of the heritability of breastbone deformation, we arrive at the following conclusions:

The heritability of the irregularity may be considered proved, with the qualification, however, that it probably consists in a lessening of the capacity for utilizing food-calcium in the formation of a sturdy bony structure. In special circumstances the characteristic need not necessarily appear in the phenotype. Removal of the perches in general use with consequent diminution of stress on the breastbone may suffice to reduce the appearance of the curvature very considerably.

Because of the pronounced dependence of the phenotypic manifestation of this character on the environment, a single analysis will scarcely lead to a factorial interpretation of this case. The question must remain open for the present whether we are dealing with a dominant or a recessive factor. However, the statistical picture obtained above is unequivocal and the assumption of the heritability of this character may be taken as certain.

The earlier as well as the present investigations have brought proof that deformation of the breastbone is an irregularity, a "beauty" defect but not a character deleterious to production so that it deserves no exaggerated attention in production poultry breeding.

VARIATIONS OF AND SELECTION FOR CEREBRAL HERNIA IN FOWLS

By PROF. ALESSANDRO GHIGI, *Director, Institute of Zoology, University of Bologna, Bologna, Italy*

In 1914 I published a series of researches on the inheritance of cerebral hernia in fowls[1], explaining the effects of selection on a hydrid-bird population which had been obtained by mating a Padua cock, with cerebral hernia and weighing 2,400 grams, to a Game bantam hen of 600 grams' weight, for the purpose of producing a bantam breed with a well-developed crest, as in the Paduas. The chief object of selection was to favor the development of the cranial cupola, and success was obtained in the sixth generation. The extension of this cupola is conditioned by multiple factors. As early as the second generation, in some individuals the upper part of the skull was somewhat elevated in comparison with that of normal fowls; the extension of the cupola of one female was superior to that of its progenitor of the true Padua breed. However, considering the large number of individuals reared with orthogenetic criterion, that is, mating only specimens

[1] GHIGI, ALESSANDRO, Ricerche sulla eredità dell'ernia cerebrale dei polli in correlazione ad altri caratteri. Archivio Zool. 8. 1914.

with a very well-developed cupola, I obtained in the fifth generation an average value nearly as high as that of the sire and in the sixth generation a superior value. Hence, six generations occurred before selection had exhausted its capacity of improvement.

Because of consanguinity, it was not possible to maintain this group beyond the seventh generation, because many eggs had an imperfect shell, normal and fertile eggs gave a poor hatch, and the mortality of mature hens was considerable.

These biological facts, together with the outbreak of the Great War, forced me to abandon these experiments after the publication of the above-mentioned paper.

DESCRIPTION AND RESULTS OF EXPERIMENTS BEGINNING IN 1921

After the foundation of the Stazione Sperimentale di Pollicoltura at Rovigo, of which I became the director, I recommenced, in 1921, the experiments abandoned at the outbreak of the Great War. I was able to carry them on much more extensively than before, because I had sufficient space and brooding pens at my disposal.

I mated a black Padua cock with a Java hen and a buff Padua cock with a golden Sebright hen, obtaining from the first mating a black progeny and from the second mating, by segregation from one another, two types of progeny, golden and buff ones.

The results of these matings were analogous to those published in 1914, but they were much more numerous and rapid, as the cranial cupola reached its highest development in the average of the population in five generations. However, these fowls, called Bantams Ghigi, especially golden and buff colored, were not real bantams but were intermediate, and the weight of the cocks was frequently higher than 1,000 and 1,200 grams, respectively. As, in addition, they had assumed the morphological aspect of true Paduas, I decided to repeat the entire experiment by crossing the best birds obtained by orthogenetic selection, with true Java and Sebright birds.

I made the following recrosses: Male Java Bantam × female black Bantam Ghigi; and male Bantam Ghigi × female golden Sebright Bantam.

The progeny of both these recrosses are forming today two groups which have reached a rather high degree of purity of cerebral hernia and which are discussed at some length in this paper. However, as the preparation of the skulls from Rovigo confirmed what I had already published concerning my experiments made in 1907 and 1914, I preferred, in this second series of researches, to study the brains. The most interesting results in this connection have been presented by me to the Exposition of Genetics at the Sixth International Congress of Genetics at Ithaca in 1932.

In studying this material I have been assisted by several coworkers in my laboratory, as follows:

1. An anatomical and embryological study of the hernial brain, carried on by Dr. Teresa Siemoni.
2. A biometrical study of the population with hernia of hybrid origin, obtained by the direct mating of a Padua cock with a Java hen and of a Padua cock with a Sebright hen, for the purpose of studying the mutability of the brain produced by an experimental cross. This research has been carried on by Dr. Romilda Fattovich.
3. A biometrical study of the effects of selection on the brains of the two series, black and golden, produced by recrossing Bantams Ghigi with a Java cock and a Sebright hen, respectively, carried on by Dr. Marta Grandi.

Comparison of hernial with normal brain

The hernial brain was studied for the first time by Hagenbach in 1893 and afterwards by Klatt in 1910, both studies being incomplete and with a rather small amount of material. The brain of fowls with cerebral hernia is somewhat longer and narrower than that of normal fowls, and its single parts have a topographically different position. Seen from the back, it resembles more the brain of a reptile than that of a normal bird.

In the brain of fowls with cerebral hernia, the telencephalon has advanced and is situated nearly above the ocular bulbs, in the interorbital space; the cerebral peduncles are more evident in the middle and anteriorly to the optical lobes, having become much longer, and it is precisely in correspondence to the said peduncles that the greatest lengthening of the brain manifests itself. Moreover, the interhemispheric incision is less evident than in the normal fowl. The distance between the telencephalon and the little brain makes the epiphysis plainly visible from the back. Besides, the diencephalon remains completely free posteriorly to the telencephalon, and this fact is perhaps the reason for the restraining of the hemispheres, which, however, cover the different parts of the diencephalon in normal birds.

The optic lobes, which in normal fowls are somewhat compressed between the telencephalon, the diencephalon, and the little brain, so as to remain somewhat crushed, assume in fowls with hernia a somewhat rounder shape in their anterior parts, because they are situated at a distance from the hemispheres, whereas they preserve posteriorly contact with the little brain.

It seems that the little brain, too, has been influenced by the general lengthening of the encephalon, because it is narrower and longer than in the normally shaped encephalon. Its anterior half is lengthened, reaching more forward, and is less prominent. The number of the dorsally visible circumvolutions is higher than in the normal one (Siemoni).

According to the modifications of the exterior shape, there are also inner structural differences, especially in the aspect of the ventricles.

In many brains the two halves are asymmetric;

in others, the shape and structure are intermediate between the normal and the transformed one. These belong to specimens on which positive selection has exercised a partial action.

Formation of hernia

The first evident sign of the formation of a hernia can be observed, during embryonic development, after 150 hours of incubation, that is, at the age of 6¼ days by means of a different behavior of the rudimentary telencephalon. Whereas in the normal fowl this telencephalon forms two prominent swellings situated at the anterior extremity of the head, above the optical lobes, in the fowl with hernia it forms a protuberance which is most developed dorsally and in an anterior direction. Furthermore, the cerebral lobes are larger in their median transversal diameter than in normal embryos, and whereas they grow posteriorly narrower, their anterior end is more rounded and their vault more convex, so that the whole telencephalon becomes much more prominent between the two optical lobes, than in the normal bird (Siemoni).

When the chicken is hatching, the hemispheres are coming out of the skull, thus forming a true hernia. The bony cupola is a secondary formation which will be developed only after the chicken has finished its growth, at the age of about 3 months, as I have already shown in my paper of 1914.[2]

Variations in measurements of hernial brain

I have already mentioned the fact that I obtained at Rovigo a population with cerebral hernia of hybrid origin, selected during several generations, but not satisfying because of its too high weight. I wished to study the statistical behavior of the hernia so as to value the variability in a population of known origin. Dr. Fattovich has measured 245 brains with hernia and has found that within each series of the various measures there exists a noteworthy homogeneousness. The respective curves are unimodal, and the coefficient of variation is rather low. The distance between the cranial margin of the chiasm and the caudal extremity of the fourth ventricle, considered as a fundamental measure for the values expressed in the index of hernia, vary little, as does also the broadness of the hemispheres. The variation of the measure which corresponds to the anterior half of the brain is considerably higher, and this is precisely the part most modified by the hernia.

The measurements of the brains of males are slightly less than those of females, but this difference has very little biometrical value (Fattovich).

The variation studied in these researches can be interpreted as caused by multiple factors. The elongation of the brain, manifested by the cerebral hernia, is then due to numerous factors whose action is summarized, and by means of selection the number of positive factors is considerably increased in the genotype. On the contrary, when a population varies in hereditary characters beyond the limit of that variation which has proved to be characteristic of that determined species or race, it is most probable that this variation is due to hybridism.

Experiments with golden breed in 1933

In 1933 the Bantams Ghigi were recrossed with the golden Sebright hen, and up to 1937 five generations have been reared; the brains examined numbered 285.

No observations could be made on the F_1 birds, as the brains were all quite normal, the hernia being of a recessive character.

The F_2 birds examined are 20 in number, 13 of which are males and 7 females. In only 2 males is there a slight elongation of the cerebral hemispheres as well as of the peduncles, and one of them is asymmetric. The relation $\frac{C}{A}$ between the distance from the anterior limit of the optical chiasm to the anterior margin of the little brain on the ventral side (C) and the length of the brain measured from the base of the little brain to the apex of the hemispheres (A), is, on an average, 0.696. This value is nearly the same as that of normal fowls (Leghorns), which is 0.702. The average ratio $\frac{H}{A}$, in which H signifies the broadness of the brain on the height of the optical lobes, is 0.727, nearly the same as that of the Leghorns, which is 0.725.

The F_3 fowls, numbering 59, are of varying development; the average ratio $\frac{C}{A}$ is 0.562, varying from 0.700 to 0.460. Hence, the hernia is rather well developed in comparison with that of the F_2 birds, and evident results have been obtained by selection. Of 33 males, 18 are asymmetric, as are 5 of 19 females; the total percentage of asymmetry is 40.67. The ratio $\frac{H}{A}$ also gives analogous results: the average is 0.558 with a range of 0.418 to 0.740, the coefficient of variation being 14.22. Of 134 F_4 birds, 78 are males and 90 females. The average ratio $\frac{C}{A}$ is 0.539, nearly the same as the preceding one, with extreme values of 0.630 and 0.470. Hence, the variation is somewhat less than that of the preceding generation. The total percentage of asymmetric brains decreased to 16.66; the coefficient of variation was 6.07.

Of the generation F_5, 32 birds were studied, and 5 of them were kept as reproducers. The average ratio $\frac{C}{A}$ is 0.541, with extreme values of 0.581 and 0.460. In comparison with the preceding generation the difference is smaller, especially in view of the fact that the brains with the best-developed

[2] See footnote 1.

hernia were not examined. The coefficient of variation is 5.52 and the percentage of asymmetric brains 9.37.

Experiments with black breed in 1934

In 1934, the Bantams Ghigi were recrossed with a black Java cock, and by 1937 four generations with a total number of 115 brains had been studied.

In the F_1 birds the hernia is completely absent and the ratio $\frac{C}{A}$ is 0.726. The F_2 birds number 54, and the average ratio $\frac{C}{A}$ is 0.610, with extreme values of 0.500 and 0.700. The coefficient of variation is 8.48, a rather low value, which demonstrates the limited formation of cerebral hernia. The percentage of asymmetry is 14.81.

The F_3 birds number 45. The average ratio $\frac{C}{A}$ is 0.570, with extreme values of 0.500 and 0.780. The coefficient of variation is 9.99, and the percentage of asymmetric brains is 44.87.

Only 16 F_4 birds were examined, the others having been kept as reproducers. The average ratio $\frac{C}{A}$ is 0.567, with extreme values of 0.500 and 0.620. The coefficient of variation is 6.85; the percentage of asymmetric brains is 25.

There is very little difference in the ratio $\frac{C}{A}$ between the F_3 and F_4 birds in the selection of the black breed, and an analogous result was observed between the F_4 and F_5 birds in the golden breed. The reason for this difference between the two series is evident: contrary to what was to be expected, the golden breed has not produced any bird with well-developed hernia in the F_2 generation, and this generation has behaved in the same manner as the F_1 generation (Grandi).

CONCLUSION

In drawing a general conclusion from the behavior of the length of the brain (cerebral hernia) in these birds, I wish to call attention to the fact observed by myself among the 14 F_2 birds as early as 1907. One had a completely developed hernia, whereas in the golden breed used in 1934 none of the 20 F_2 birds showed a somewhat distinct hernia.

Theoretically, one may say that three generations, beginning with the F_2, are necessary for producing, in nearly all birds, a hernia which is rather uniformly developed and varying within rather narrow limits. One additional generation is necessary if F_2 birds are not accessible to selection and one less generation if in the F_2 generation there are some birds which possess several of the multiple genetic factors. Favorable possibilities increase with a greater number of F_2 birds. The cerebral hernia, caused by a greater length of the brain, is a recessive and multiple character which manifests itself only in the F_2 generation for the first time. The third generation is the most varying one and affords the easiest selection, which makes it possible to obtain a homogenous fourth generation in comparison with the third one. Successively, the effects of selection become less and less variable and the breed can be considered stable.

SUMMARY

In a series of experiments, a Padua cock with cerebral hernia was mated to a Game bantam hen for producing a bantam breed with a well-developed crest, as in the Paduas. The cranial cupola, determined by multiple factors, had in the fifth generation a value approximating that of the sire and in the sixth generation a superior value. In the seventh generation the birds of the group died as a result of consanguinity.

Another series of experiments was made by mating a Padua cock to Java and Sebright hens. The results of these matings were analogous but were obtained much faster as the cranial cupola reached its highest development in the fifth generation. However, these fowls, called Bantams Ghigi, were not real bantams but were of an intermediate stature and weight.

In a third series of experiments, Bantams Ghigi were mated to Java and Sebright bantams; from these matings two breeds resulted in which the development of the cerebral hernia has reached a rather high degree of purity.

With this material the following studies were made: (1) An anatomical and embryological study of the hernial brain; (2) a biometrical study of the population with hernia of hybrid origin, in order to determine the mutability of the brain; (3) a biometrical study of the effects of selection on the brains of the progeny from the recrossing of Bantams Ghigi with a Java cockerel and a Sebright hen.

Theoretically, one may say that three generations, beginning with the F_2, are necessary for producing, in nearly all birds, a hernia which is rather uniformly developed and varying within rather narrow limits. One additional generation is necessary if F_2 birds are not accessible to selection and one less generation if in the F_2 generation there are some specimens which possess several of the multiple factors for cerebral hernia. The cerebral hernia, determined by a greater length of the brain, is a recessive and multiple factor which manifests itself only in the F_2 generation. The third generation is the most varying one and permits the easiest selection, from which a very homogeneous fourth generation can be obtained in comparison with the third one.

RESULTS OF FIVE YEARS OF SELECTION FOR VIABILITY IN POULTRY FLOCKS[1]

By D. R. MARBLE, *Associate Professor of Poultry Husbandry, The Pennsylvania State College, State College, Pennsylvania, U. S. A.*

Laying-flock mortality in all sections of the United States has increased steadily during the past decade. Available records of pathologists show that this increase has been due to a group of diseases centering around fowl paralysis or lymphomatosis. Methods of prevention or cure have been difficult to work out because of the wide variety of symptoms manifested and the lack of knowledge concerning the transmission of the various forms of the disease.

The reports of Roberts and Card (1926) on the inheritance of resistance to bacillary white diarrhea and of Lambert and Knox (1932) on the resistance to fowl typhoid demonstrated the possibility of developing strains of fowls resistant to the fowl paralysis complex. The encouraging results of these two investigations were responsible for the present study at the Pennsylvania State College, in which the primary objective has been to improve the viability of the two breeds maintained on the college poultry farm. The development of a line susceptible to the fowl paralysis complex was not undertaken.

PROCEDURE

Previous to 1932 the selection of breeders was based on egg production and hatchability as major factors with some attention given to body and egg weights. The pullets were selected carefully for housing in laying pens, and a heavy culling for egg production and egg size was made late in the spring. Since 1932 all breeders have been selected on the basis of family viability, with egg production, egg and body weights, and hatchability as secondary factors. The complete family of pullets has been either housed or culled. Females for pedigree pens have been selected from those families showing the best viability. Birds with poor egg production and small egg size have been discarded whenever it was possible to do so without sacrificing viability. Males used in the pedigree matings have been, in most instances, cockerels selected on their sisters' viability during that portion of the laying year prior to January 1. During the 5 years of selection on this basis, more than 4,900 adult birds were placed in laying pens and their viability on a family basis studied for a 365-day period.

Management conditions and rations of the layers were not altered during this 5-year period. Brooding conditions varied for only 5 of the 67 different brooding units. These 5 variations were made for the purpose of studying the influence of management on adult mortality.

The results reported in this paper were accomplished primarily by selection within the strains developed in previous years at the Pennsylvania State College. Only one male from another strain was used in the 5-year period, and he headed a pedigree pen of Barred Plymouth Rocks in the fourth generation of the study. The viability of his progeny was approximately the same as that of the entire flock for the 1936–37 trap-nest year.

Brooder pens, 12 by 20 feet in size, were used for all brooding except the five units noted. The chicks had access to wire-bottomed sun porches when weather conditions permitted. All chicks were pedigree-hatched and wing-banded. From 250 to 300 chicks were placed in each pen. Males were removed at 5 to 6 weeks of age, and the pullets, at 10 weeks of age, were placed on a clover or alfalfa sod range in summer shelters. Pullets were housed at sexual maturity in laying pens equipped with trap nests. Both adult mortality and egg production are calculated on the 365-day period following the completion of the rearing period. Since age at first egg varies for different families it was necessary to establish a constant termination for the rearing period. An age of 150 days was set for the Single-Comb White Leghorns and 170 days for the Barred Plymouth Rocks.

Intermixing of families to permit the maximum distribution of the disease by natural infection has been practiced. The only segregation has been the separation of breeds throughout the rearing and laying periods and of different ages in the brooder houses and range shelters.

RESULTS

The mortality data (which include actual deaths and culling because of illness) for the 6-year period preceding the beginning of selection for viability are shown in table 1. The mortality during this period (1927 to 1932) was caused primarily by fowl paralysis and its associated neoplastic conditions. Birds culled for low egg production or small egg size were not included in the flock-reduction figures shown in this table.

Data on the adult mortality for the 5 years following the change in the method of selection of breeders are presented in table 2. They show a highly significant decrease in losses, as compared with those of the preceding 6-year period. The flock reduction in the Single-Comb White Leghorns in 1937 was approximately half that shown in table 1 for the 6-year period 1927–32. Likewise, the mortality in the Barred Plymouth Rocks in 1937 was only half of the average mortality in 1927–32.

The marked reduction in the rate of mortality

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was not accompanied by any apparent shift in the comparative importance of losses due to the paralysis complex. A very large proportion of the deaths occurring in these two flocks on the Pennsylvania State College poultry farm is still due to the ravages of some form of the paralysis complex, even though the total flock reduction is only half as much as formerly.

An analysis of the mortality in the various families involved in this study shows that the increase in viability was accomplished by the development of families which possessed greater genetic resistance to the various forms of the paralysis complex or a greater constitutional vigor which aided in establishing immunity through exposure to a natural infection. The fact that hatchability has not changed materially and that early chick mortality has increased slightly would suggest that probably the lower adult mortality was not due to an improvement in constitutional vigor. Available evidence would suggest that a degree of genetic resistance has been developed through the selection of breeding males and females from the most viable families.

TABLE 1.—*Laying-flock mortality for the 6-year period preceding selection for viability*

Year hatched	Single-Comb White Leghorns		Barred Plymouth Rocks	
	Birds housed	Total mortality	Birds housed	Total mortality
	Number	*Percent*	*Number*	*Percent*
1927	1,211	39.4	366	39.1
1928	852	36.3	361	40.1
1929	1,054	29.0	424	47.7
1930	931	38.6	624	41.8
1931	766	47.9	348	73.3
1932	528	47.6[1]	214	50.0
Average	890	39.8	390	48.7

[1] Approximately one-fourth of this mortality was due to prolapse and "pickouts."

TABLE 2.—*Mortality, egg production, egg weight, body weight, and age at first egg for 5-year period, 1933-37*

Year hatched	Mortality of adult progeny of—		Egg production	Egg weight	Body weight at first egg	Age at first egg
	Hens	Pullets				
	Percent	*Percent*	*Number*	*Grams*	*Pounds*	*Days*
	Single-Comb White Leghorns					
1933	30.4	....	190.6	57.0	3.93	165.0
1934	24.8	46.4	185.1	56.9	3.75	167.9
1935	31.0	....	198.5	56.9	3.88	169.1
1936	20.8	....	201.4	56.6	3.93	176.2
1937	20.1	....	205.2	56.5	3.86	171.9
	Barred Plymouth Rocks					
1933	36.0	46.1	200.2	58.3	5.12	176.6
1934	58.3	49.5	185.4	55.9	4.91	173.9
1935	39.5	....	199.6	54.8	5.02	177.0
1936	20.4	....	202.9	56.5	5.36	201.4
1937	24.6	....	219.0	56.0	4.90	181.4

Fifty-six families of full sisters were housed in the Single-Comb White Leghorn laying pens in the fall of 1933. At the completion of the laying year only 2, or 3.6 percent, of the original 56 families had 90 percent or more of their numbers still living. In the first generation of the Barred Plymouth Rocks selected for viability, only 1 of 33 families had a viability of 90 percent. The number of viable families has gradually increased year by year until in the fifth generation 40.6 percent of the Single-Comb White Leghorn families and 29.3 percent of the Barred Plymouth Rock families showed at least 90 percent of viability. In this analysis only families of five or more full sisters have been considered.

Influence of age of breeders

No attempt has been made to differentiate between breeders in their second laying year and those in later laying years. The only grouping according to age was made in the 1934 and 1935 generations when some pullets in their first laying year were used in certain pedigree matings. Cockerels, selected on the same basis as those used in the hen matings, headed the pullet matings.

Viability of the adult fowls hatched from hen breeders was higher on the average than for those hatched from pullet breeders, as shown by table 2. The advantage in favor of the progeny of hen breeders is very marked in the Single-Comb White Leghorn flock. Chicks were hatched from both hen and pullet breeders in two successive generations of Barred Plymouth Rocks. Progeny of hen breeders were more viable in the 1933 generation but less viable in the 1934 generation. These data substantiate in general the conclusions of Kennard and Chamberlin (1934) and Gildow, Williams, and Lampman (1936).

Hays (1928) concluded that any particular breeder possesses the same ability to transmit desirable inherited characters to its offspring when it is a pullet as at any later time in its life. Directly comparable evidence on this point is not available because of the use of different males in repeat matings of various females. The use of older breeders, both males and females, on farms where paralysis is a problem appears to be justified because many birds do not show their susceptibility prior to their use in the breeding pen when mated as pullets.

Influence of egg production and other economic factors

It was necessary to sacrifice egg production and egg size somewhat when the method of selection of breeding stock was changed in 1933. Data presented in table 2 with respect to these various economic factors indicate that there was a significant drop in egg production in the case of the Barred Plymouth Rocks in the second generation of progeny. Some decline was experienced in the Single-Comb White Leghorns but it was too small to be statistically significant. The increases shown in both breeds in the third generation and again in the Barred Plymouth Rocks in the fifth year of selection are statistically significant.

Changes in body weight at the time the first egg was laid were not significant, and the changes in age at first egg between 1933 and 1937 were barely significant. In egg weight, the Single-Comb White Leghorns showed a slow but steady decline, but even the total decline over the 5-year period was too small to be statistically significant. The egg weight of the Barred Plymouth Rocks in 1933 was unusually great when compared with that of the preceding years. The decline in the second generation was significant, but the average egg weight for 1934–37 is comparable with that of the years preceding 1933.

Changes in age at first egg have been insignificant except for the marked increase shown by both breeds in 1936. The increase was very marked in the Barred Plymouth Rocks, but even in the Single-Comb White Leghorns the odds are greater than 30:1 that the increase was not due to chance. By plotting the frequency curves for 1936 and comparing them with the other years, it is evident that the increase was due to the presence of a larger number of extremely late maturing birds and a general shifting of the entire frequency to a higher level.

When all the economic factors presented in table 2 are considered the benefits far exceed the losses. The highly significant increase in viability was obtained without serious losses in any of the other economic factors, even though only secondary consideration had been given to these other factors in the selection of breeding stock.

DISCUSSION

The consideration of viability of the family in the selection of breeding stock appears to be entirely practical. However, the poultryman must recognize that resistance to disease is specific for a particular disease only. A flock highly resistant to the paralysis complex may prove to be very susceptible to any of a number of other diseases. The use of a breeding program in which family viability is considered has its value even though no major disease problem exists on the farm. The advantage of including this factor in the selection of breeders is much more apparent, however, when an outbreak of a disease occurs against which genetic resistance can be developed.

The results of this study point out the desirability of selecting breeding birds from the viable families when an outbreak of fowl paralysis occurs on a breeding farm. Selection of viable families will not entirely eliminate the occurrence of the disease in later generations, but it can hold the disease in sufficient check so that a profitable poultry business can be continued. Complete disposal of the current flock and replacement with new stock of unknown resistance may result in still heavier losses. The use of stock known to be resistant may aid in speeding up the development of resistance.

SUMMARY

Adult mortality in poultry flocks at the Pennsylvania State College was extremely high during the 6-year period 1927–32. This high mortality was due to various forms of the fowl paralysis complex and included iritis, paralysis, and tumors. Since 1932 all breeders have been selected on the basis of family viability, with egg production, egg size, body weight, and hatchability as secondary factors. During the 5 years of selection on this basis, more than 4,900 adult birds of two different breeds have been placed in laying quarters and their viability on a family basis studied for a 365-day period.

Management conditions and rations have been the same during this 5-year period. The results reported have been accomplished by selection from within the strains.

The laying-flock mortality during these 5 years of selection has been decreased from 39.8 percent in the Single-Comb White Leghorns for the 6-year average for 1927–32 to 20.1 percent in 1937. The decrease in the Barred Plymouth Rocks has been from 48.7 percent for the 6-year average to 24.6 percent in 1937. Cases of paralysis, tumors, and leucosis still constitute a large proportion of the mortality, but the percentage of families showing high viability has increased from year to year.

The data indicate that losses from fowl paralysis can be decreased gradually by the use of breeders from families that show resistance to the disease and by the use of hen breeders in preference to pullet breeders.

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REDUCTION OF MORTALITY IN FOWLS BY BREEDING

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INTRODUCTION

This paper reports the results of 3 years' work in which an attempt was made to reduce mortality in fowls by breeding. In the White Leghorn pullets used at Cornell, mortality during the years 1928 to 1930 varied from 17 to 23 percent during the first laying year. From 1931 to 1934 it varied from 41 to 44 percent. In 1935-36, the first year of this experiment, the mortality from 160 to 500 days of age was 64 percent. This figure was somewhat higher than for previous years because no culling of pullets was done at any time. It is obvious that this strain presented adequate material in which to demonstrate the possibilities of reducing mortality by breeding. Prior to the spring of 1936, when the first selected generation was hatched, no breeding for increased viability had been attempted. By September 1938 the first two selected generations had finished their laying year, and they are reported upon in this paper.

Breeders were selected from families in which mortality was lowest. With the prevailing high mortality there was little choice of good breeding material for the first generation. Only one or two females were available, among whose offspring there had been no mortality whatever to the end of December. Pullets were chosen from some of the better families, but even in these mortality was as high as 10 or 12 percent by the end of December.

Other characters of economic importance, including egg production, size of bird, and size of egg, were considered equally as much as low mortality. In general, no breeders were used unless they had laid 200 eggs or more during the first year, with eggs weighing 56 grams or more. When pullets were used, corresponding ratings in egg production and egg size were required.

A particular effort was made to avoid using families in which losses from neoplasms of any kind had occurred. This procedure was desirable because most of the mortality as shown by table 3, was caused by neurolymphomatosis, lymphocytoma, leucosis, and allied conditions.

All families under test had uniform environment during incubation, brooding, rearing, and in the laying houses. No pullets were culled at housing time except those belonging to families numbering fewer than 8 or 10, which were considered too small for an accurate measure of viability. Pullets from different pens and strains were mixed entirely at random in the houses. No culling was done during the test period, which was from 160 to 500 days of age. Mortality from hatching to 160 days is not considered in this paper.

SUSCEPTIBLE STRAIN

This investigation differs from others of similar nature in that a separate line of birds was bred with susceptibility to the same diseases as it was sought to eliminate in the resistant strains. The usefulness of this strain is threefold: (1) Raising of susceptibility in one line at the same time that resistance is increased in another line constitutes a more effective demonstration of the possibilities of genetic control than would be provided by the resistant line alone. (2) Moreover, some experiment stations seeking to attain similar objectives have found that in two or three generations mortality was reduced to a point at which it was doubtful whether or not the surviving birds had been exposed to infection. If in a susceptible line mixed at random with the other birds there still occurs a high mortality, and if the neoplasms that are mainly responsible occur in the susceptible birds, there can be no question about adequate exposure of all birds in the test. (3) Mortality rates in the susceptible lines also serve as controls to show whether any improvement noticed in the resistant lines has resulted from some favorable change in the environment or may be attributed to breeding. In our experiment the susceptible stock constituted 12 percent of the whole flock in 1936 and 15 percent in 1937.

OTHER STRAINS

Another strain was begun in 1936 by outcrossing selected females of the Cornell stock to males of the Kimber strain, which had then been bred for increased viability over a period of about 8 years. In 1937 selected F_1 pullets of this stock were mated back to two of the Kimber males and two of their sons.

A third strain, B, entirely unrelated to any of the other birds, was begun in 1936, with fully pedigreed chicks hatched from unpedigreed pullets of this strain which, during the 1935-36 laying year, had been scattered at random through the Cornell flocks.

RESULTS

Reduction of mortality

In the Cornell resistant strain, deaths in the second generation were 13.8 fewer per hundred birds than in the unselected stock, which was a reduction of 21 percent in the mortality rate of 64.1 percent in the original unselected population (table 1). Since at the same time the mortality in the susceptible strain was higher by 5 birds per 100 than in the original unselected population, it is evident that the improvement noted in all other lines did not result from improvements in husbandry or from unusually favorable environmental conditions.

Following outcross of the Cornell stock to the Kimber males, there was a reduction in mortality to 34.4 percent. In the same year losses in the susceptible stock were more than twice that figure. Hybrid vigor may have been partially responsible for the low death rate in the outcrossed stock. Two of the three males used had mortality rates in their progeny of 25.4 and 29.6 percent, both lower than for any of the 15 other males on test that year. The higher mortality in this line in the second generation probably resulted from the loss of hybrid vigor. The mortality (44.1 percent) was still lower than in the second selected generation of the Cornell stock.

Strain B was evidently somewhat more resistant than the Cornell stock, but the reduction of deaths in that line by 13.5 birds per hundred, or 25 percent of the original rate in the first selected generation, is significant.

TABLE 1.—*Mortality of birds from 160 to 500 days of age in the first 3 years of the experiment*

Strain	1935–36 (unselected)		1936–37		1937–38	
	Birds	Mortality	Birds	Mortality	Birds	Mortality
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Cornell resistant	1,395	64.1	952	54.0	711	50.3
Cornell susceptible	1,395	64.1	212	70.3	319	69.0
Outcross to Kimber	1,395	64.1	342	34.4	337	44.1
Strain B	......	......	253	54.7	660	41.2
Total	1,395	......	1,759	......	2,027	......

Although mortality in 1937–38 cannot be considered low in any of the three lines being bred for increased viability, it is consistently lower than in the original unselected populations. It would undoubtedly have been still lower if the flocks had been subjected to the vigorous culling done by all good commercial poultrymen when the pullets are housed.

Age at death

Survival to 500 days, the period of testing in this experiment, merely means that death has been pushed back beyond that limit. However, the bird which dies from neurolymphomatosis at 380 days is much more resistant than that which succumbs to the same disease at 190 days, provided both were infected at the same age. Controlled experiments, in general, indicate that birds dying of neoplasms are more likely than not to have been infected long before the 160-day age at which most of ours were housed. The mean age at death of those that die is therefore a good measure of comparative resistance and of susceptibility.

In the original 1935–36 population from which the resistant and susceptible lines of the Cornell strain were selected, the mean age at death for birds dying between 160 and 500 days of age was 321 days. The data in table 2 show that in the second generation life for such fowls had been extended in the resistant line to 350.6 days, but reduced in the susceptible line to 301.8 days. The fact that those dying in the resistant line were able to survive 7 weeks longer than those in the susceptible line, when both groups were mixed entirely at random from incubation to death, is further convincing evidence of the effectiveness of the genetic attack on the mortality problem.

TABLE 2.—*Mean age at death of birds, in the Cornell lines, dying between 160 and 500 days of age*

Year of hatch	Cornell resistant line		Cornell susceptible line		Difference	Diff. / S.E.
	Deaths	Mean age	Deaths	Mean age		
	Number	*Days*	*Number*	*Days*	*Days*	
1935	895	321.0 ± 3.0	895	321.0 ± 3.0	....	......
1936	514	337.8 ± 4.1	149	292.3 ± 7.0	45.5 ± 8.1	5.6
1937	358	350.6 ± 5.0	220	301.8 ± 6.5	48.8 ± 8.2	6.0

Differences between individual breeders

One of the more interesting of many cases showing significant differences in families of individual breeders was provided by a female mated in 1937 to an untested male that it was hoped would produce viable stock. Six females yielded families large enough to test. Among 60 pullets from 5 of these birds, the mortality from 160 to 500 days of age was 71.7 percent, and 20 birds died from neoplasms of one kind or another. One of the 5 lost all her 15 daughters, 10 of them with neoplasms. The sixth female, though obviously mated to a male transmitting extreme susceptibility, lost only 1, or 5.9 percent, of her 17 daughters in the test period and that bird died of bumble foot. The odds against such a performance resulting from chance are more than 35,000:1.

Consistent breeding performance

Of the four best males, (that is, with lowest mortality in their progenies) in 1936, two still alive were used in the following year with different females. The best of 17 White Leghorn males tested in 1936 was second best among 20 tested in 1937. The other male used both years ranked third in 1936 and fourth in 1937.

Conversely, the male in whose progeny mortality (82.1 percent) was higher than that for any other family from 15 males tested in 1935 was used also in 1936 to head a pen in the susceptible line and again produced the family with highest mortality (75.2 percent) of all male progenies tested that year. The ability to survive for 2 years does not indicate the ability to produce offspring equally as viable.

Causes of mortality

Autopsies were obtained on all dead birds. In the first year they were made at the New York State Veterinary College and during the next 2 years they were made by one of us (R. K. C.).

The condensed summary of diagnoses during the second and third years of the experiment (table 3) shows that neoplasms (including leucosis, neurolymphomatosis, and tumors) caused most of the mortality. The chief difference between resistant and susceptible lines is in the incidence of neoplasms, that is, in those conditions that were first considerations in the selection of breeders.

TABLE 3.—*Condensed summary of causes of mortality in birds from 160 to 500 days of age in the Cornell lines, 1936-38*[1]

Causes of death	1936-37		1937-38	
	Resistant line	Susceptible line	Resistant line	Susceptible line
	Percent[2]	*Percent*[2]	*Percent*[2]	*Percent*[2]
Neoplasms[3]	15.4	24.4	19.1	35.7
Disorders of reproduction	11.7	11.2	7.3	6.2
Intestinal parasites	10.8	14.1	6.5	7.1
Respiratory diseases	5.6	4.9	1.1	1.2
Kidney diseases	2.4	2.9	4.2	3.1
Miscellaneous	6.7	10.6	9.8	13.5
Undiagnosed or negative	2.5	2.0	2.8	2.5

[1] Numbers of birds in the four groups are given in table 1.
[2] Based on the number of birds alive at 160 days of age.
[3] Including leucosis, neurolymphomatosis, and tumors. Paralyzed birds suspected of having neurolymphomatosis are included only when post-mortem examination confirmed that diagnosis.

Improved husbandry in 1937, including a fresh rearing range and better housing, reduced the incidence of those diseases (intestinal parasites, respiratory disorders) amenable to control by such methods, yet the incidence of neoplasms increased in both lines. This situation may be partly explained by the probability that in 1937–38 more birds escaped early death from other causes only to die later from the neoplasms to which they were susceptible. This is suggested by the increased age at death in the resistant line that year (table 2). However, although the deaths from neoplasms in the resistant line increased only from 15.4 in the first generation to 19.1 cases per 100 in the second generation, the rise in the susceptible line during the same period was from 24.4 to 35.7 cases per 100 birds. This difference further indicates the effects of the kind of selection pursued.

Table 3 gives data only for the Cornell lines but similar results and trends were found in the B and outcross lines.

SUMMARY

Results of 3 years of breeding to increase viability in the fowl are reported. Beginning in 1935 with stock in which no selection for resistance to disease had been done, the procedure has been to select breeders from families with lowest mortality under natural exposure to disease-producing agencies, and, after the first year, to use as far as possible birds proved by progeny test to transmit more than average resistance to disease. No culling has been done within families retained and all birds are tested to 500 days of age. Use of families with high incidence of neurolymphomatosis, leucosis, or other neoplasms has been avoided. All birds that died are diagnosed.

In unselected stock hatched in 1935, mortality from the time of housing to 500 days of age was 64 percent. In the first selected generation, in 1936, the corresponding figure for the period from 160 to 500 days of age was 54 percent. Females of this stock outcrossed in 1936 to males of a strain bred for high viability produced progeny in which mortality was only 34 percent during the same period. In contrast, the death rate in stock selected for susceptibility to disease was 70 percent in the first generation.

In the second selected generation, hatched in 1937, mortality from 160 to 500 days of age was 50.3 percent in the resistant line, 69.0 percent in the susceptible one, and 44.1 percent in the outcross line. The birds that died in the resistant line lived 7 weeks longer than those that died in the susceptible line. Offspring of males used in 2 consecutive years were consistently resistant or consistently susceptible in both years. The incidence of neoplasms in the second generation was 19 percent of all birds alive at 160 days in the resistant line, but 36 percent of all such fowls in the susceptible line.

NATURE OF THE HEREDITARY FACTORS FOR RESISTANCE AND SUSCEPTIBILITY TO PULLORUM DISEASE IN THE DOMESTIC FOWL

By E. Roberts, *Professor of Animal Genetics,* J. M. Severens, *Assistant in Animal Genetics, and* L. E. Card, *Professor of Poultry Husbandry, University of Illinois, Urbana, Illinois, U. S. A.*

Experimental evidence has been reported (*3, 4, 5*)[1] showing that in the domestic fowl resistance and susceptibility to infection by *Salmonella pullorum* are hereditary. The experimental results from which this conclusion is reached are briefly:

1. Selection was effective in producing strains of the domestic fowl more resistant than were unselected stocks in respect to infection by *Salmonella pullorum.*
2. The selected stocks were consistent in maintaining resistance through successive generations.
3. The F_1 generation produced by crossing resistant and susceptible stock was as resistant as the resistant parents.
4. Progeny of the F_1 × resistant stock were significantly more resistant than were the progeny of the F_1 × susceptible stock.
5. In the F_2 generation, susceptible and resistant strains were recovered by selection.
6. A susceptible male mated to susceptible females produced progeny which were much less resistant than were progeny of the same male mated to resistant females.

A study of the nature of the hereditary factors involved in resistance includes a search for the defense mechanism responsible for the difference between resistant and susceptible individuals.

Because pullorum disease in the young chick seems to be a septicemia (*1*), we thought a study of the copper content of eggs would be of value, since copper is associated with the regeneration of hemoglobin. Four lots of hens given different treatments in an attempt to control the amount of copper in the eggs were used, but the addition of copper to the diet did not increase the copper content of the eggs. Differences in copper content, however, were found among the different pens. The amounts of copper in milligrams per 100 grams of yolk were as follows: Pen 11, 0.162; pen 8, 0.139; pen 9, 0.132; pen 10, 0.112.

The survivals among inoculated chicks from these pens were 70, 60, 60, and 47 percent respectively. These results led us to attempt again to control the copper content of the eggs to determine whether it was related to resistance, but we have not been successful in this. Analyses of eggs from hens of resistant and susceptible strains failed to show significant differences in copper content.

Examination of blood from adult birds of resistant and susceptible strains showed no differences in bactericidal power. The pH values of the alimentary tract were also the same for both strains.

Table 1.—*Blood studies on resistant and susceptible chicks from the fifteenth day of incubation through the seventh day after hatching*

Strain[1]	Days after beginning of incubation	Chicks	Red cells	White cells	Neutrophils		Lymphocytes	
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*	*Number*	*Percent*
R......	15	4	1,810,000	8,500	7,750	92.0	400	4.0
S......		4	1,877,000	9,600	8,115	83.0	585	8.0
R......	16	4	1,845,000	5,750	5,350	93.0	360	6.0
S......		4	2,130,000	6,750	6,280	93.0	250	4.0
R......	17	4	2,095,000	8,000	7,255	90.5	565	6.5
S......		4	2,170,000	4,500	3,680	82.0	620	14.0
R......	18	4	2,220,000	6,500	4,900	75.0	1,325	20.5
S......		4	2,173,000	11,000	9,626	87.3	1,113	9.3
R......	19	4	2,346,000	8,667	7,340	84.0	1,073	12.7
S......		4	2,250,000	7,500	7,260	96.0	240	4.0
R......	20	4	2,485,000	10,250	9,137	88.0	780	8.5
S......		4	2,406,000	12,233	11,583	93.3	530	4.3
R......	21	4	3,165,000	15,750	12,760	81.0	2,513	16.0
S......		4	2,993,000	17,000	16,107	94.3	697	4.3
R......	22	17	2,630,000	18,853	11,194	57.3	6,181	34.8
S......		17	2,921,000	20,150	14,214	70.4	4,400	21.9
R......	23	21	2,545,000	16,470	9,086	54.8	6,178	37.6
S......		21	2,624,000	18,450	11,162	58.0	5,788	34.2
R......	24	14	2,472,000	16,464	8,830	52.7	6,348	39.2
S......		13	2,486,000	20,153	12,410	61.6	5,872	29.6
R......	25	9	2,365,000	17,833	9,533	51.8	7,140	41.7
S......		9	2,455,000	16,550	7,948	47.0	7,427	45.8
R......	26	13	2,365,000	16,308	5,655	34.4	9,251	56.9
S......		12	2,330,000	18,583	6,109	34.0	10,839	57.6
R......	27	10	2,306,000	17,100	5,203	29.4	11,002	65.8
S......		8	2,431,000	16,500	5,530	34.6	10,309	61.2
R......	28	9	2,366,000	21,660	8,055	37.4	12,310	56.8
S......		7	2,474,000	19,357	6,397	32.0	12,281	64.6

[1] R=resistant, S=susceptible.

Our attention was next turned to the different kinds of blood cells. When a suspension of *Salmonella pullorum* was introduced into the

[1] Italicized numerals in parentheses refer to Literature Cited, p. 54.

blood of immunized birds, the bacteria became associated with the lymphocytes. This finding suggested the possibility that the lymphocytes might be associated with resistance.

From a study of the blood of resistant and susceptible individuals, it was found that the lymphocytes are present in greater number and percentages in the resistant chicks from the eighteenth day of incubation through the third day after hatching (table 1 and figure 1).

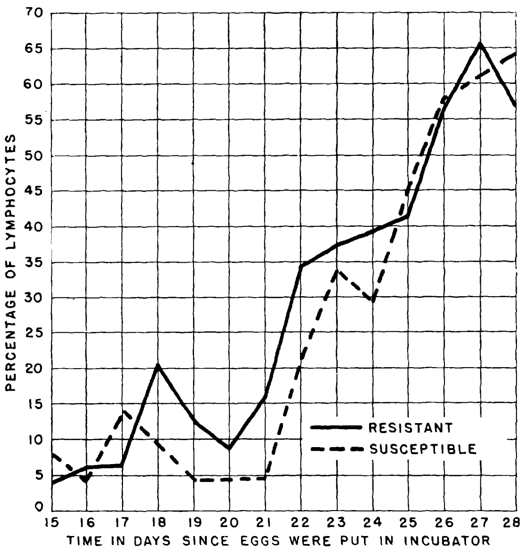

FIGURE 1.—Percentage of lymphocytes in resistant and susceptible chicks from the fifteenth day of incubation through the seventh day after hatching.

TABLE 2.—*Relation of age of chicks to resistance to pullorum disease (subcutaneous inoculation)*

Age of chicks when inoculated (days)	Chicks	Survival
	Number	*Percent*
1	24	16.2
2	24	35.5
3	24	34.4
4	24	58.1
5	24	63.4
6	60	93.3

The number and percentage of lymphocytes increase with age in both resistant and susceptible strains until about the fifth to sixth day after hatching. During this time resistance to pullorum disease also increases. Inoculation of chicks 6 days after hatching results in little mortality (table 2). Is this change in resistance during the first few days associated with the change in the number of lymphocytes?

If the lymphocytes constitute a defense mechanism, a reduction in lymphocyte number ought to be followed by increased susceptibility.

Hussey (*2*), Spurling and Minot (*6*), and Taylor, Witherbee, and Murphy (*7*) found that the lym-

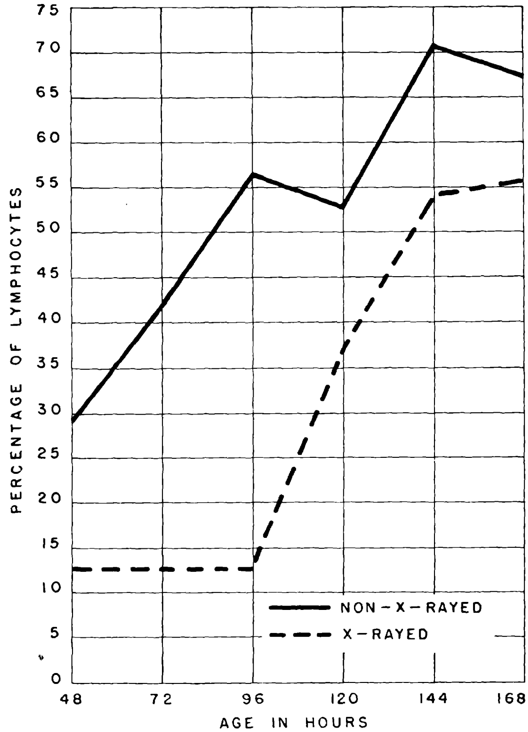

FIGURE 2.—Effect, on percentage of lymphocytes, of X-raying chicks when 1 day old.

TABLE 3.—*Effect of X-rays on lymphocytes in chicks*

Chicks X-rayed when 1 day old

Age of chicks in hours when blood counts were made	Chicks	Results from chicks not X-rayed (control)		Results from X-rayed chicks	
		Leucocytes per cubic millimeter	Lymphocytes	Leucocytes per cubic millimeter	Lymphocytes
	Number	*Number*	*Percent*	*Number*	*Percent*
48	6	33,000	28.7	14,000	12.6
72	6	21,000	41.6	17,000	12.7
96	6	28,000	56.5	19,000	12.9
120	6	19,000	52.3	12,000	36.7
144	6	24,000	70.5	19,000	54.0
168	6	22,000	67.1	15,000	55.4
Chicks X-rayed when 6 days old					
168	4	40,000	26.6	21,000	4.2
192	4	14,000	54.0	10,000	5.3
216	4	12,000	72.7	13,000	10.4
240	4	28,000	48.8	11,000	48.0

phocytes in mammals with which they worked could be decreased in number without decreasing the number of other blood cells. We found the same results in chicks following X-raying (table 3 and figure 2). The dose was 360 *r* units. The birds were X-rayed for 2 hours at 65 kilovolts, 5 milliamperes, and at a distance of 30 inches. When 1-day-old chicks were orally inoculated, 65 percent of the chicks not X-rayed and 42.9 percent of the X-rayed chicks survived. With subcutaneous inoculation the survivals of the two groups were 45 and 0 percent respectively. The controls X-rayed but not inoculated had a survival of 100 percent (table 4).

Pullorum disease is a disease of young chicks. If infection does not occur during the first few days after hatching, the typical disease is not produced and mortality is low. When 5 or 6 days old the chicks are highly resistant. X-rays were effective in reducing the lymphocytes in chicks 6 days after hatching, as they were in chicks 1 day old (table 3). A greatly increased susceptibility was found in these older chicks which had been X-rayed.

TABLE 4.—*Effect of X-rays on resistance of chicks to pullorum disease*

Inoculation	Not X-rayed		X-rayed	
	Chicks	Survival	Chicks	Survival
	Number	*Percent*	*Number*	*Percent*
Chicks X-rayed at 24 hours of age				
Oral	10	50.0	23	26.0
Do	20	65.0	40	15.0
Do	20	75.0	50	60.0
Do	50	64.0	50	56.0
Total	100	65.0	163	42.9
Subcutaneous	40	45.0	40	0.0
None	10	100.0		
Chicks X-rayed at 6 days of age				
Subcutaneous	30	96.6	30	6.6
Do	30	90.1	30	36.6
Total	60	93.4	60	21.6

Six-day-old chicks which were X-rayed and inoculated subcutaneously had a survival of 21.6 percent. Those that were inoculated but not X-rayed had a survival of 93.4 percent (table 4).

These facts suggest that the difference between resistant and susceptible chickens is due to an inherited differential in the number of lymphocytes at the time of greatest susceptibility to pullorum disease, which is immediately after hatching.

It is entirely possible, however, that the decreased resistance in X-rayed chicks was not due to a decreased number of lymphocytes but to some other change produced by X-rays concomitantly with the reduction in lymphocytes. But if the lymphocytes are not a defense mechanism some other change is occurring concomitantly with the increase in lymphocytes with age which is defensive in nature.

The alimentary tract may also be a defense mechanism because subcutaneous inoculation produces a greater mortality than does oral inoculation. In oral inoculation, however, the lymphocytes may have the opportunity of destroying some of the bacteria before they have had the opportunity of entering very far into the body tissues. This may account for the lesser mortality from oral than from subcutaneous inoculation.

SUMMARY

Evidence that resistance and susceptibility of the domestic fowl to pullorum disease are related to the number of lymphocytes was obtained from blood studies of resistant and susceptible chicks. This evidence consists of the following:

The number of lymphocytes is greater in resistant than in susceptible chicks.

Resistance in both resistant and susceptible chicks increases with age and the number of lymphocytes also increases.

When the number of lymphocytes in day-old chicks is reduced by X-rays, susceptibility is increased.

When 6-day-old chicks which have become resistant because of age are X-rayed, the number of lymphocytes is decreased and they become susceptible, as they were when younger.

From blood studies of chicks from the fifteenth day of incubation to the eighth day after hatching, it was found that the number of lymphocytes in the resistant chicks become greater than in the susceptible ones at about the eighteenth day of incubation.

These facts suggest that the difference between resistant and susceptible chickens is due to an inherited differential in the number of lymphocytes at the time of greatest susceptibility to pullorum disease, which is immediately after hatching.

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EIN SEMILETALER FAKTOR BEI HÜHNERN, DER MISSBILDUNGEN DER WIRBELSÄULE UND DES BECKENS VERURSACHT

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In einem Zuchtstamm polnischer Grünfüssler-Hühner erschien infolge weitgehender Inzucht eine Anzahl von Tieren mit spezifischen Missbildungen der Wirbelsäule und des Beckens.

Mit zunehmendem Alter führte die sich entwickelnde Missbildung schliesslich zu vollkommener Bewegungsunfähigkeit.

Anatomo-pathologische Untersuchungen des Skeletts zeigten eine nach links gerichtete Verkrümmung des distalen Teiles der Wirbelsäule. Diese Missbildung war besonders ausgeprägt in der Lendenwirbel-Gegend.

Analoge Verunstaltungen wurden auch im Beckenknochenbau beobachtet. Dieser Teil des Skeletts war S-förmig gekrümmt, und das Beckengewölbe bildete einen deutlich wahrnehmbaren Buckel.

Die beschriebenen pathologischen Veränderungen führten in ihren extremen Formen zu vollkommener Bewegungsunfähigkeit, weil die Gliedmassen nach rückwärts und aussen gebogen waren.

Nach der Feststellung, dass die erwähnte Missbildung nicht auf Fütterungseinflüsse oder Umgebung zurückzuführen ist, war es klar, dass deren Auftreten durch erbliche Anlagen verursacht wird.

Aus der hinsichtlich der Letalanlage durchgeführten Erbanalyse (F_1-Paarungen und Rückkreuzungen) ergab sich, dass die beobachteten Missbildungen des Skeletts durch einzelne rezessive Gene verursacht werden. Aus durchgeführten Rückkreuzungen ergaben sich 91.25 Prozent normale und 8,75 krüppelhafte Vögel.

SUMMARY

In a strain of Polish greenfeet-fowl, a certain number of birds appeared having specific malformations of the vertebral column and of the pelvis because of extensive inbreeding.

With increasing age the developing malformations finally led to complete inability of motion.

Anatomic-pathological examination of the skeleton showed a curvature towards the left of the distal part of the spine. The malformation was particularly noticeable in the lumbar spinal region.

Analogous malformations were also observed in the bony structure of the pelvis. This part of the skeleton was curved in S-shape, and the pelvic arch formed a distinct humpback.

The described pathological changes, in their extreme form, caused complete immobilization because the limbs were bent backwards and out.

After ascertaining that these malformations could not be referred to feeding or surrounding conditions, it was clear that they are caused by hereditary factors.

The analysis of the mode of inheritance (F_1-matings and backcrosses) showed that these malformations of the skeleton are due to several recessive genes. Backcrosses produced 91.25 percent normal and 8.75 percent crippled birds.

GENETIC ASPECTS OF EGG WEIGHT OBSERVED DURING INBREEDING EXPERIMENTS[1]

By N. F. Waters,[2] *Poultry Husbandry Subsection, Iowa Agricultural Experiment Station, Ames, Iowa, U. S. A.*

A study extending over a 12-year period (1926–37) was made of the effect, on egg weight, of inbreeding, top-crossing, and crossbreeding several breeds of fowl. The breeds used were inbred and random-bred White Leghorns, Rhode Island Reds, Light Brahmas, and New Hampshires. The inbred White Leghorn stock is described by Waters and Lambert (1936).

Progeny tests were made on 137 sires and 695 dams which produced 3,266 daughters. Data on egg weight are available for each sire's sisters, half-sisters, dam, maternal aunts, and his daughters. Data are also available for each dam, her sisters, half-sisters, dam, maternal aunts, and her daughters.

There was no intentional selection for egg weight throughout this experiment. During the first 5 years, except for mortality, no females were discarded until at least 10 months after the first egg was laid. During the last 7 years no females were discarded until at least 1 year after laying began.

[1] Journal Paper No. J-624 of the Iowa Agricultural Experiment Station, Ames, Iowa, Project No. 54.

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Waters (1937) has shown that the time to obtain a measure of the first year's maximum egg weight is after the bird has attained its maximum body weight, at about 10 months of age. During the early phases of this study egg weights were obtained only during the months of January to May. The birds used during the early phase were all approximately 10 months of age or more when egg weights were obtained and, therefore, the average egg weight of these birds was used in this study. After 1931 the egg weight of each bird was determined by obtaining the average egg weight from a sample of eggs laid at least 1 week each month for 5 months after the bird had reached maximum body weight at 10 months of age.

For estimating the genetic portion of the variance the method described by Lush and Arnold (1937) was used. For all breeds studied, approximately 55 percent of the variance between the weights of eggs produced by those dams mated to a given sire could, by this method, be described as the genetic portion of the variance. This variance, as calculated, is as follows: For all breeds, 55.4 percent; for all breeds except the inbreds, 73.9 percent; and for the inbreds, only 45.6 percent.

If the method used in determining the genetic portion of the variance is biologically sound, then egg weight is a highly hereditary trait. Further, with such a high genetic portion it should be possible with careful selection for the average breeder to make rapid progress in the improvement of egg weight. This conclusion agrees with the findings of many practical poultry breeders.

Evaluating the relationship for egg weight between various combinations of maternal ancestors and progeny suggests that the association between dam and progeny is of greater value than the association between various other combinations of maternal ancestry and progeny.

Evaluating the relationship for egg weight between various combinations of the paternal ancestors and progeny suggests that the association between the sire's full sisters and his progeny is of greater value than between various other combinations of the paternal ancestry and progeny. The correlation between the sire's full sisters and his progeny is 0.42, which is highly significant. This correlation suggests that a high association exists between these two variates. Examination of the data show, however, that this correlation is more obvious than useful. If the total population is divided into different egg-weight groups according to the system of breeding, the values of the correlations change and for the most part are not significant.

In table 1 is presented, by years, the average egg-weight distribution with means for all inbreds. Waters and Lambert (1936), reporting on many of the same inbred birds included in the present sample, showed that as the inbreeding coefficient increased there was no significant trend toward heavy or light egg weight. The addition, however, of nearly 700 birds from 1936 to 1938 with proportionate increases in the inbreeding coefficient shows that there is a significant decrease in egg weight for all families.

The top-cross hens reported in this study were obtained by crossing inbred Leghorn sires selected from different families with random-bred Leghorns. The eggs from the top-crossed hens showed no significant increase or decrease in egg weight over those of the inbreds or random-breds.

Inbred sires with records of light-weight eggs in their ancestry were crossed with Light Brahma, Rhode Island Red, and New Hampshire hens that produced heavy eggs. The crossbreds produced eggs significantly above intermediate in weight between the inbreds and purebreds, a result which supports the hypothesis of Waters and Weldin (1929) that there are probably certain genes dominant for heavy egg weight.

TABLE 1.—*Average egg-weight distribution with means for all inbred females*

Year	Number of eggs of indicated weight in grams																																	Total	Mean
	40.5		42.5		45.5		46.5		48.5		50.5		52.5		54.5		56.5		58.5		60.5		62.5		64.5		66.5		68.5		70.5		72.5		
1937			2	2	8	2	6	13	10	21	20	[1]**13**	13	25	19	10	7	4	2	1	3		1							1				183	51
1936		1		1	3	2	6	9	5	7	8	7	9	11	2	5	3	2	2	4	2													89	51
1935			3	6	6	6	8	8	9	17	9	16	**9**	15	10	7	1	1	4	2	1	2	2											142	52
1934			2	1	2	3	2	7	3	17	12	18	13	**16**	21	20	8	10	4	8	2	4	1		1									175	53
1933					1		1	4	1	8	4	12	14	17	14	**10**	11	11	4	3	5	7	6	3	4	2	2			1				145	55
1932			1	1		2	6	4	7	11	12	19	20	32	24	27	**23**	32	21	29	14	19	9	17	6	7	6	4	1	2	3		1	360	56
1931						1			4	1	7	5	7	8	15	17	20	**19**	11	21	12	13	7	5	5	2		1	1					181	57
1930									1	2	3	6	5	6	**0**	2	3	1	3	2	1	2	2	1										40	54
1929	1				1			3	2	5	4	18	6	11	**12**	14	14	11	1	5	1	6	2		1									118	54
1928				1	1	2	4	7	5	11	19	28	25	36	**30**	42	29	39	16	17	8	4	3	7	2	1	1		1	1				320	54
1927								1	2	1	1	7	3	7	8	5	7	**8**	5	10	5	4	4	4	4	2			1			1		90	57
1926												1	2		4	5	5	6	**5**	9	5	2	3		2									49	58
	40		42		44		46		48		50		52		54		56		58		60		62		64		66		68		70		72	1892	
	Weight in grams																																		

[1] Bold type shows approximate location of mean.

For a number of years many breeders and hatcherymen have been following the procedure of selecting only those eggs which weigh 56 grams or more. This method of selection does not take into consideration the inherent ability of the male to transmit egg weight. Furthermore, hatchery-flock males are generally obtained from many different sources, with no information available on either the ancestry or progeny of these males. It is reasonable to ask what this method of selection will accomplish.

Table 2 shows the results obtained when all dams are grouped, irrespective of the sires with which they were mated, into heavy- and light-egg-weight classes. The combining of these data into one group approximates the progress a breeder should make in any one year if no attempt has been made to select males that have been either sib-tested or progeny-tested for egg weight. Dams were selected from the total sample and subdivided into two groups: (1) Those with an egg weight of less than 56 grams and (2) those with 56 grams or more. Each group was further divided into classes of 4 grams each. As the egg weight of the dam increased or decreased there was a corresponding increase or decrease in the mean of the progeny with the exception of those in the lightest-egg-weight class. The average egg weight of all dams is included in this table also.

TABLE 2.—*Comparison of mean egg weights of dams and progeny when the dams, irrespective of mating, are grouped into heavy- and light-egg-weight classes*

Dams classified according to egg weight (grams)	Birds	Mean egg weight of—	
		Dam	Progeny
	Number	*Grams*	*Grams*
43.9 or less	8	42.0	51.3
44.0 or less	137	45.8	49.8
48.0 or less	759	49.2	51.7
52.0 or less	1,609	51.5	52.7
all	3,011	54.6	54.1
56.0 or more	1,402	59.8	55.7
60.0 or more	612	62.7	56.9
64.0 or more	197	65.8	58.5
68 or more	39	69.7	60.1

All the dams, grouped irrespective of sire, whose average egg weight was 56 grams or more produced progeny that laid eggs averaging 55.7 grams. All dams, regardless of the weight of their eggs, produced progeny having an average egg weight of 54.1 grams. The progeny from the selected dams, producing eggs weighing 56 grams or more, averaged 1.6 grams more in average egg weight than did the progeny from the unselected group. This difference, which measures the amount obtained in attempting selection, is highly significant. The difference of 1.4 grams found between the progeny of the selected dams (below 56 grams) and the unselected group which also measures the effect of selection, is highly significant.

These results indicate that selection of dams with an average egg weight of more than 56 grams would have increased significantly the average egg weight of the progeny. No significant change was found from year to year when this selection was not made.

Selection of dams laying eggs 60 grams or more in weight resulted in progeny that produced eggs averaging 56.9 grams. Every increase in the weight of the dams' eggs resulted in an increase in the weight of the eggs produced by the progeny. Conversely, as the egg weight of the dam decreased the egg weight of the progeny decreased.

These data grouped, then, according to the dam's egg weight suggest that a breeder should select dams whose egg weight is 60 grams or more in order to produce progeny whose eggs have an average weight of 56.9 grams, or about 2 ounces per egg. Such rigid selection immediately eliminates a large percentage of eggs for hatching purposes. Under ordinary hatchery management all eggs weighing less than 56.6 grams, or 24 ounces to the dozen, or more than 70 grams, or 29 ounces to the dozen, are not used for hatching purposes. This procedure greatly reduces the available number of hatching eggs. A careful selection of dams having an average egg weight of more than 60 grams will result in an increased number of progeny whose egg weight will satisfactorily meet the trade requirements established for either hatching or market purposes.

TABLE 3.—*Results obtained from mating sib-tested sires with dams whose average egg weight is (1) less than 56 grams or (2) 56 grams or more*

Classification of sires	Mean egg weight of full sisters of sires	Egg weight of dams	Number of dams	Mean egg weight of—	
				Dam	Progeny
	Grams	*Grams*		*Grams*	*Grams*
Sires whose full sisters' average egg weight was less than 56 grams	52.4	Less than 56	976	50.9	52.1
	53.1	56 or more	472	59.6	55.0
Sires whose full sisters' average egg weight was 56 grams or more	57.8	Less than 56	352	52.7	53.4
	58.9	56 or more	729	59.8	55.9

Table 3 shows the results obtained from mating the indicated groups of sires with dams whose average egg weight was (1) less than 56 grams and (2) 56 grams or more.

The mating of sires whose full sisters' average egg weight was less than 56 grams with dams whose egg weight was (1) 56 grams and (2) 56 grams or more resulted in progeny with a mean egg weight of 52.1 and 55.0 grams, respectively, the difference being highly significant. When sires whose full sisters' average egg weight was 56 grams or more were mated with the two groups of dams, the difference between the mean egg weight of their progeny was also highly significant. When the two groups of sires were mated with the dams that produced eggs less than 56 grams in weight, there was no significant difference in the mean egg weight of their progeny. Likewise, when the two groups of sires were mated with the dams whose eggs weighed 56 grams or more, there was no significant difference in the mean egg weight of their progeny. These results indicate that the selection of dams was more effective than the selection of sires, as measured by their full sisters' egg-weight averages.

SUMMARY

A study extending over a 12-year period was made of the effect on egg weight, of inbreeding, top-crossing, and crossbreeding several breeds of fowl. The breeds used were inbred and random-bred White Leghorns, Rhode Island Reds, Light Brahmas, and New Hampshires. Progeny tests were made on 137 sires and 695 dams which produced 3,266 daughters. Data on egg weights are available for each sire's sisters, half-sisters, dam, maternal aunts, and his daughters. Data are also available for each dam, her sisters, half-sisters, dam, maternal aunts, and her daughters.

Evaluating the relationship for egg weight between various combinations of maternal ancestors and progeny suggests that the association between dam and progeny is of greater value than the association between various other combinations of maternal ancestry and progeny. Evaluating the relationship between various combinations of the paternal ancestors and progeny suggests that the association between the sire's full sisters and his progeny is of greater value than between various other combinations of the paternal ancestry and progeny.

The results indicate that the selection of dams with an average egg weight of more than 56 grams would have significantly increased the average egg weight of the progeny over that obtained when no selection was practiced. Selection of dams is more effective than selection of sires as measured by their full sisters' egg-weight averages.

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CROSSBREEDING IN THE DOMESTIC FOWL

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In the fields of plant and animal genetics, hybridization has been and may be accomplished in four ways: (1) Crossing individuals of different genera, species, or subspecies; (2) crossing inbred individuals of different inbred lines; (3) crossing individuals of different breeds and varieties; (4) a combination of (2) and (3), the crossing of inbred lines from different breeds and varieties.

The progeny from crosses of different genera, species, or subspecies in the plant kingdom have been used with some degree of success in the formation of new types of plants. In the animal kingdom, however, progeny from such crosses in large animals, whenever they are obtained, usually prove to be without economic value although the mule is an outstanding exception. Many crosses have been made between different species and subspecies of birds and in a few cases between individuals of different genera.

Phillips (1913, 1915, 1916, and 1921), Smith and Haig-Thomas (1913), Cutler (1918), and Tiniakoff (1933 and 1934) made crosses of genera, species, or subspecies between the duck and the pheasant, between the chicken and the pheasant, or between the chicken and the peacock. More recently, Warren and Scott (1935) and Quinn, Burrows, and Byerly (1937) crossed the chicken with the domestic turkey but were unable to hatch any of the hybrid embryos. Such results indicate that genus, species, and subspecies hybrids among birds offer only slight possibility of showing any economic merit.

The production of hybrids by crossing individuals from different inbred lines has been very successful in the field of plant genetics. Corn breeders have produced their economic hybrids by this method of crossing. Although the crossing of inbreds has proved to be highly successful in plant breeding, it has not been tried to any extent with chickens because of the great difficulty that has been encountered in obtaining inbred lines. Furthermore, there have been few, if any, published reports of systematic well-organized attempts to test the few lines of inbred chickens that have been obtained. Most poultry geneticists appreciate the fact that the production of inbred lines is important, but the expense involved in such experiments has served as a distinct handicap to this undertaking. Even if the expense and facilities were provided the chances of obtaining successful inbred lines for economic crosses are limited. In addition to this, the time required would be a deterrent to such a project. It appears, therefore, that one of the most promising means of obtaining meritorious hybrid chickens has been neglected for these reasons.

One of the latest developments in poultry breeding is the attempt to create superior progeny by crossing different breeds and varieties of domestic fowl. Such hybrids are not to be confused with the manner in which successful hybrids (progeny of crossed inbred lines) are produced by corn breeders. This report is a comparison of standardbred chickens and hybrids that were produced by crossing different breeds and varieties of chickens.

Pearl and Surface (1910) published the first extensive report of crossing different breeds of the domestic fowl. Reciprocal crosses were made between the Barred Plymouth Rock and Dark Cornish. They found that the hybrid pullets were more or less intermediate in the production of eggs from November 1 to March 1 and that the hatchability of the hybrid embryos was better than that of the embryos of the standardbred fowl. The hatchability of the parental stock, however, was exceedingly low and it would be expected that there would be an increase in the hatchability of the hybrid embryos. Byerly, Knox, and Jull (1934) showed that crossing standardbred breeds is likely to change the hatchability from that characteristic of the parental breeds, depending on the level of hatchability of the eggs from the standardbred breeds that were used in the matings. In other words, if the hatchability of the parental stock is low, cross-breeding such stock would improve hatchability. If it were high—above 80 percent—in the parental stock, crossing might lower hatchability as often as it increased it, depending on the genetic factors for hatchability carried by the parent breeds.

Warren (1927 and 1930) reported that hybrid pullets resulting from crosses between Single-Comb White Leghorns and the Jersey Black Giant and Single-Comb White Leghorns and Rhode Island Reds hatched better, grew faster, and produced more eggs than did the parental stocks.

Knox[1] found that the F_1 hybrids from crosses of the Single-Comb White Leghorn with the White Plymouth Rock, with the Rhode Island Red, and with the White Wyandotte did not attain the production of the parental breeds when the latter averaged more than 200 eggs per year.

Because of the interest in cross-breeding and the diversity of results thus far obtained, the experiments reported were undertaken at the Animal Husbandry Experiment Station, Agricultural Research Center, Beltsville, Maryland. In such experiments the number of different crosses that can be tested is decidedly limited because of the amount of time involved, the lack of housing facilities, and the expenditure of money that would be necessary in order to complete the project successfully. Because of these conditions, the experiments were divided into groups. In the first group no attempt was made to use similar parental stock to produce both the standardbred and crossbred progeny, whereas in the second group they were produced from similar parental stock. In the first group, therefore, it was possible to test a greater number of crosses than in the second group.

In the first group, approximately 100 eggs were obtained from each of several poultry breeders in different sections of the United States. These eggs were incubated in the same incubator and hatched at the same time. The chicks were reared under similar conditions, the pullets being kept until the end of their first year of production (365 days from the date of first egg). The data in table 1 give the average results obtained.

The results obtained from the hybrid progeny were compared with the results obtained from Single-Comb White Leghorn and Single-Comb Rhode Island Red stock.

In another group of experiments a procedure similar to that of the preceding experiments was used except that similar parental stock was used to produce the standardbred and hybrid progeny. This, of necessity, limited the number of breeds used. The breeds included Single-Comb Rhode Island Reds, Light Sussex, White Wyandotte, crosses of Rhode Island Red males mated to Light Sussex and White Wyandotte females, and 2 three-way crosses—Light Sussex males mated to F_1 hybrid females (Rhode Island Red males and White Wyandotte females) and White Wyandotte males mated to F_1 hybrid females (Rhode Island Red males and Light Sussex females). The data in table 2 give averages of the results obtained.

Although the results of these experiments do not verify previous opinions of the results of cross-breeding, they do not mean that this method of approach for the production of superior stock should be discarded. When compared with the many unsuccessful crosses discarded in corn-breeding work, the results in these experiments are only a small beginning in the cross-breeding of poultry. It is quite possible that the stock used in these crosses lacked the essential factors for producing successful hybrids. The results, however, do show that considerable expense and knowledge of the parent stock and how they combine in crosses are necessary for the production of successful hybrids. This work indicates that much of the success depends on the quality of the standardbred chickens used in the cross and that the use of inferior parental stock merely produces another hybrid of doubtful quality and value.

[1] Unpublished data, Iowa Agricultural Experiment Station, 1924–31.

TABLE 1.—*Comparison of White Leghorn, Rhode Island Red, and hybrid chickens*

Item	Egg production		Egg weight	Hatchability			Body weight			
	Pullets	Average eggs produced	Average egg weight	Eggs set	Fertile eggs set	Total eggs set	Males	Average weight of males at 10 weeks	Pullets	Average weight of pullets at 11 months
	Number	*Number*	*Grams*	*Number*	*Percent*	*Percent*	*Number*	*Grams*	*Number*	*Grams*
White Leghorn	71	201.3	54.7	1,240	70.0	65.9	307	608.7	152	1,825.4
Rhode Island Reds	108	201.5	53.5	510	63.1	51.6	141	589.8	132	2,471.3
Light Crosses[1]	67	139.4	54.1	958	74.5	65.9	69	568.7	117	1,989.1
Heavy Crosses[2]	88	165.7	55.4	2,069	74.6	65.5	102	718.9	159	2,405.4

[1] These crosses involved matings of Single-Comb White Leghorn males to Single-Comb Rhode Island Reds, Black Minorca, and White Plymouth Rock females. One crcss was included in which White Plymouth Rock males were mated to Single-Comb White Leghorns.

[2] These crosses included progeny from Single-Comb Rhode Island Red males mated to Barred Plymouth Rocks and their reciprocal cross, and Single-Comb Rhode Island Red males mated to White Wyandottes. Eggs from these crosses were obtained from four different breeders. The crosses included also, 3 three-way crosses, F_1 Red-Leghorn males mated to Light Sussex females, White Wyandotte males mated to F_1 Red-Sussex females, and Light Sussex males mated to F_1 Red-Wyandotte females.

TABLE 2.—*Comparison of Rhode Island Red, Light Sussex, White Wyandotte, and their hybrid progeny*[1]

Breed name or cross	Pullets	Average egg production	Average egg weight	Average body weight of—			
				Males	Males at 10 weeks	Pullets	Adult pullets at 11 months
	Number	*Number*	*Grams*	*Number*	*Grams*	*Number*	*Grams*
Rhode Island Red	234	202	53.3	747	650	319	2,480
Light Sussex	335	134	55.7	814	602	462	2,391
White Wyandotte	80	142	53.0	319	566	288	2,060
Red males x Light Sussex females	366	168	55.0	391	690	274	2,300
Red males x White Wyandotte females	217	161	54.5	378	642	251	2,200
3 Way Light Sussex males x F_1 Red-W. Wyan	100	150	54.0	164	642	141	2,191
3 Way W. Wyan. males x F_1 Red-Sussex	90	160	54.7	134	689	130	2,263

[1] No adult pullet weights taken in 1933; no culling of female progeny from the time of hatching to the end of the laying year.

SUMMARY

The results of the experimental work reported indicated that (1) the quality of the parental stock had considerable influence on the quality of the hybrid progeny; (2) different strains of the same varieties of chickens produced different results; (3) the average hybrid was superior in body weight only in the case of heavy crosses; (4) the average hybrid chicken from purchased stock did not have so high an egg production as did the average White Leghorn and the Rhode Island Red stock; (5) the best hybrid progeny were obtained from crosses between Rhode Island Reds and Barred Plymouth Rocks and Rhode Island Reds and White Wyandottes, these crosses obtained from good-quality parental stock producing practically as well as the standardbred White Leghorns and Rhode Island Reds; (6) although data on mortality are not given, the viability of the hybrids in general was superior to that of the standardbred chickens.

In another part of the experiment it was shown that the egg production of the F_1 hybrids is intermediate, being approximately 165 eggs per year, whereas one of the parental breeds, the Rhode Island Red, produced pullets that averaged 202 eggs and the other parental breed, either the Light Sussex or White Wyandotte, produced pullets that averaged 134 and 142 eggs, respectively, per year. The hybrids in general weighed more at about broiler age but were not heavier at 11 months of age (adult body weight).

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LATERAL ASYMMETRY IN THE FOWL

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In a former paper (1938) we reviewed 8 laterally asymmetric birds (half-siders) previously reported among domestic fowl and added 5 new cases (A, B, C, D, and E). These 13 birds could be segregated into two classes: (1) Those in which the average difference in long-bone measurements between the sides was small, generally less than 4 percent, and (2) those in which this difference was large and readily noticeable, being from 10 to 15 percent. We argued that the small difference, as seen in class 1, was due to the elimination of an autosome at the first cleavage division, and the large difference, as seen in class 2, was the result of nondisjunction at the same stage, an autosome being lost from one side and gained in the other.

In this paper six additional cases of mosaicism in the fowl and recorded, three being typical examples of lateral asymmetry and three being restricted mosaics, a small area of the body in the latter exhibiting an atypical characteristic. Of the three true half-siders, two are in class 1. The first, designated case F, in continuation of the alphabetical classification adopted in the former paper, is an Old English Game Bantam female with one yellow leg and one white one, the dividing line between white and yellow flesh clearly bisecting the body. The difference in size is 3 percent. The second, case G, has a difference in size of 2 percent but does not show laterality in distribution of flesh or feather pigment. It represents the first reported case in class 1, in which size asymmetry only has occurred. The third half-sider, case H, belongs in class 2, the long bones on the left side being, on the average, only 88.5 percent as long as those on the right. Like most of the asymmetric fowl previously reported, it is yellow and white in flesh, the smaller left side being yellow. The specimen is a typical male in external appearance as well as in internal structure. It is an F_1 from a cross of a Light Sussex female × Rhode Island Red male. It possesses the typical silver plumage with scattered red feathers which characterize males from this cross. There is slightly more red on the smaller left side, probably owing to a loss of modifying genes linked with white flesh. It is similar to the case described by Crew (1928) except that the autosomal loss and gain have been from left to right rather than from right to left.

The three restricted mosaics comprise two Columbian patterned males, being F_2's from an original cross of Brown Leghorn female × Light Sussex male, and one Columbian patterned female, being an F_1 from the same cross. The males are white in the flesh and leg with the exception of a small streak of yellow which runs down the posterior part of the left shank, occupying about one-fourth of the total shank area. They were, in all probability, zygotically heterozygous for white flesh (*Ww*), the *W* chromosome being eliminated from a small area of the limb bud during early developmental stages. As might be expected these males do not show a lateral difference in size. The female mosaic, in color a typical F_1, lacks the main wing feathers, both primaries and secondaries, on the left side. This defect was noticed at about 3 weeks of age and persisted to maturity and throughout successive adult molts (fig. 1). The defect is not identical with any known heritable characteristic. The flightless birds reported by Warren (1937) are characterized by broken flight feathers in the heterozygous condition and near-nakedness when homozygous. Moreover, flightless is dominant, and it is difficult to understand how a chromosome aberration would produce the condition, especially since the flightless gene was not carried by the parents. The condition of the remiges in our specimen is similar to that produced by the "naked" gene reported by Hutt (1938), but it cannot be the specific expression of this gene since the latter is recessive and sex-linked and any female carrying it would be featherless. If the condition is attributable to a localized somatic chromosome loss, as seems most probable, it is either not a gene-specific trait or the expression of a hitherto unreported and probably recessive gene. In this connection it may be noted that in expression the characteristic is similar to the "apterous" condition reported by McCrady in the guinea fowl. It may be that a similar although hitherto unreported recessive gene existing in the fowl was carried by this particular individual and became expressed when its dominant allele was eliminated when a chromosome was lost during cell division in the left-wing region.

HERITABLE NATURE OF ASYMMETRY

Perhaps the most significant evidence which these new cases afford is the definite indication that the tendency to chromosomal aberration, undoubtedly the underlying cause of lateral asymmetry and mosaicism in the fowl, characterizes certain families and thus appears to be inherited. Although the mechanism of transmission cannot be demonstrated as simple Mendelian, we feel that the evidence we possess is adequate support for assuming that the abnormality can be transmitted.

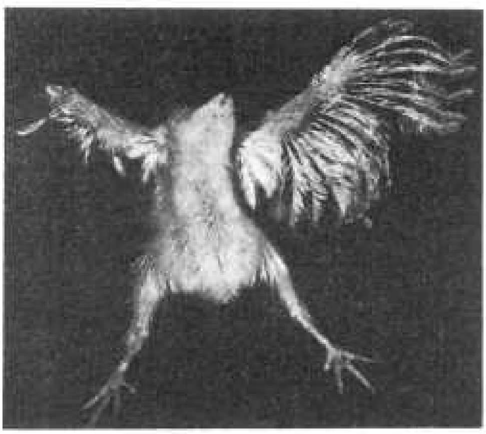

FIGURE 1.—Mosaic female 3 weeks old, showing absence of left remiges.

One of our original half-sider males with white and yellow flesh, (case C in our original report) was mated to 3 Brown Leghorn hens. Slightly more than 50 chicks were produced by the 3 hens, among which was included the mosaic lacking flight feathers on the left wing, already described; This female had 12 normal siblings. She, in turn, mated to a half-brother out of the same abnormal sire, produced 24 normal chicks and the asymmetric female, case G, already described. Thus this family includes one asymmetric individual in each of two generations, the abnormals comprising 5.3 percent of the families in which they occurred. The two white-legged males with yellow-streaked shanks are also descendants of case C. One, like case G, is an F_2 out of the original cross (case C male × Brown Leghorn female) but from different F_1 parents; this male had 49 normal siblings. The other is out of an F_1 dam backcrossed to an unrelated half-sider with white and yellow flesh (case B in our original report) and had 5 normal siblings. Thus we have four new cases of mosaicism, all descendents of case C and having a total of 90 normal siblings. The mosaics thus constitute 4.4 percent of the families which produced mosaics. When all families in the same line of descent are included, there are 349 normals and 4 mosaics, the latter constituting only 1.13 percent. Although no accurate figures are available showing the incidence of mosaics among the population at large, it is without question considerably lower than in our strain, and there is little doubt but that the chromosomal aberrations responsible tend to run in families. The relationship of these various birds is shown in the straight-line pedigree in figure 2.

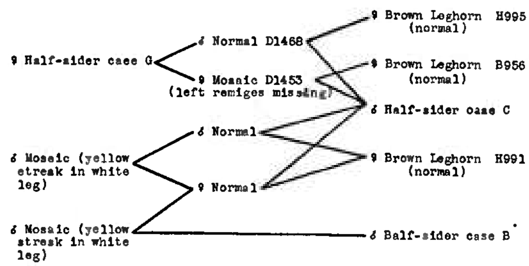

FIGURE 2.—Straight-line pedigree showing relationship of the abnormal individuals.

DISCUSSION

Each of the three new cases of bilateral asymmetry discussed in the present paper falls distinctly into one or the other of the two classes previously postulated for such fowl by Crew and Munro (1938) and can be fully explained on the basis of chromosomal elimination for class 1 and nondisjunction for class 2. They thus greatly strengthen our hypothesis. At the same time these cases, along with the three regional mosaics, also provide evidence which, when considered in conjunction with that previously extant, suggests that our postulate is limited in the scope of its application.

In the first place it seems unlikely that maldistribution of chromatin material is confined to the first mitotic division following formation of the zygote. The fact that bilateral mosaics have been almost exclusively reported in the past is probably merely because they are more apparent and readily recognized. Regional chimeras are probably equally as common if not more so, this probability being borne out by the three cases herein recorded. Again, although lateral differences in distribution of pigments in either flesh or feathers have accompanied all class 1 birds previously reported, it seems probable that this finding likewise has been due to ease of detection.

In fowl homozygous for genes controlling pigment formation, i.e., in pure breeds, loss of a chromosome should not produce a clear-cut bilaterality in pigment distribution but should, nevertheless, affect skeletal structures. The size asymmetry in such birds can be recognized only by handling and measuring or carefully comparing leg lengths, and for this reason simple chromosome loss in purebred individuals practically always escapes detection. Where the chromosome carrying the dominant allele of an expressed pigment in a heterozygote is lost, however, the recessive characteristic becomes expressed on the side from which the chromosome is lost, and the resulting lateral difference in color makes the individual clearly identifiable. Thus birds in class 1 have practically always been pigment mosaics, but that lateral size asymmetry of the same order as that which exists in these pigment mosaics can occur without pigment alterations is shown by the present case G. It seems probable that such cases are relatively frequent but undetected in purebreds. When class 2 birds, the result of nondisjunction, are found among purebreds the great discrepancy in size between the sides makes the bird easily detectable despite the absence of pigment differences, as illustrated by cases of Macklin (1923), Hutt (1937), and case E of Crew and Munro (1938). It seems probable, therefore, that the actual frequency of class 1 individuals is far greater especially relative to class 2 than the recorded cases indicate.

One of the most striking points in connection with this subject is the frequency of the white and yellow flesh mosaics. The high incidence of such cases is undoubtedly partly accounted for by the fact that individuals heterozygous for white flesh are of relatively frequent occurrence. This statement applies especially to fowl in England, where the sex-linked Sussex-Red cross is very popular and where most of the flesh-color mosaics have occurred. Nevertheless, the frequency of this type of half-sider is so high as to make it appear that the autosome which carries these flesh color genes is particularly susceptible to aberration. Furthermore, and what is fundamentally significant, this autosome appears to be directly concerned at least with sex differentiation if not sex determination, since unquestionably it is this autosome and not the sex chromosome which is the cause of the gynandromorphism of our case D (figs. 3 and 4). The difference in degree of yellow pigmentation between the shanks of case E in the same report indicates that the same autosome is involved in this gynandromorph, a pure Rhode Island Red. In fact, with the exception of Vecchi's (1936) gynandromorph, there is nothing which indicates that the same autosome may not be responsible for all recorded cases of sexual bilaterality, viz., cases of Macklin, Hutt, and cases D and E of Crew and Munro.

In originally setting forth our postulate concerning the existence of two more or less distinct quantitative classes with respect to the lateral size differential and ascribing them, i.e., classes 1 and 2, to chromosome elimination and nondisjunction, respectively, we, perhaps somewhat naively, alluded to any one of the many fowl chromosomes. Although no direct evidence is thus far available, it is perhaps best to point out that the particular

FIGURE 3.—Gynandromorph, case D, showing difference in lateral size. Smaller left side, female; right side, male, showing coarser skeletal structures including spur.

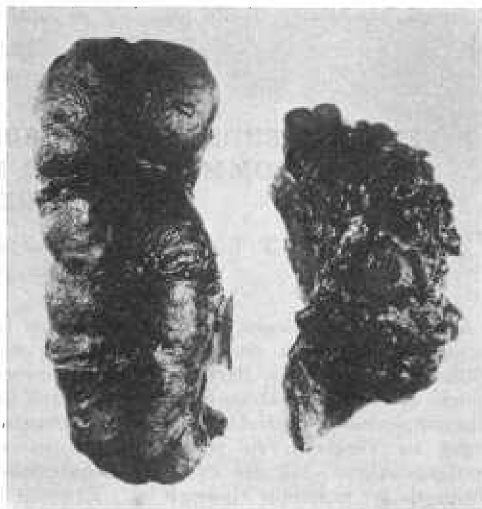

FIGURE 4.—Gonads of case D: Left, normal resting ovary; right, lobulated testis containing spermatogenic tubules and sperm.

effects brought about by the loss or gain of a chromosome will largely depend on the particular chromosome concerned. Our hypothesis has been based very largely on evidence provided by mosaics with white and yellow flesh and may be, and probably is, restricted in application to mosaics resulting from aberrations in this particular autosome only. In fact, it is by no means certain that the loss of a chromosome will always cause a decrease in size or, conversely, that its gain will cause an increase. The most complete evidence in respect to the alterations produced by the loss or gain of single chromosomes is that recorded by Blakeslee and Belling (1924) in *Datura stramonium*. The situation in the fowl is probably somewhat similar, and we may expect the somatic alterations produced by the loss or gain of single chromosomes to depend on the individuality of the chromosome incriminated. Our postulation concerning the existence of two classes, their basic causes—chromosome elimination and nondisjunction—and especially the swing toward the male sex in the trisomic side of class 2 females, applies only to the autosomal white and yellow flesh genes.

SUMMARY

Six new cases of mosaicism in the fowl are recorded, three being true laterally asymmetric birds (half-siders) and three restricted or regional mosaics. Of the former, two are in class 1 and one in class 2. These classes are sharply defined, differing in the degree of lateral skeletal asymmetry and previously ascribed by us to chromosomal elimination and nondisjunction, respectively.

The definite segregation of all asymmetric fowl thus far recorded into one or the other of these two classes lends strong support to our hypothesis. However, the theory should probably be limited in application to aberrations in the autosome carrying the white and yellow flesh genes since it is based on evidence derived almost entirely from half-siders with white and yellow flesh.

Lateral asymmetry in the fowl is characteristic of certain families, and thus the tendency to chromosomal aberration is apparently inherited.

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VERGLEICHENDE UNTERSUCHUNGEN ÜBER DIE VORHERSAGE DER NACHKOMMENLEISTUNG MIT HILFE VON AHNENTAFELN UND KURZSIPPENTAFELN

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Aufgabe der vorliegenden Untersuchungen ist es, die 3 Methoden der Erbgutschätzung von Hähnen 1) durch den Partner-Nachkommenvergleich, 2) durch die Ahnentafel und 3) durch die Kurzsippentafeln hinsichtlich ihrer Übereinstimmung in Vergleich zu setzen. Dabei ist zu berücksichtigen, daß der Partner-Nachkommenvergleich der sicherste Maßstab ist. Er stellt ja bereits den tatsächlichen Zuchterfolg eines männlichen Zuchttieres im Vergleich zu seinen ihm angepaarten weiblichen Tieren hinsichtlich der hervorgebrachten Eileistung unter Beweis. Es muß deshalb auch möglich sein, die anhand der Ahnentafel wie auch der Kurzsippentafel (Ahnen- + Ahnengeschwistertafel) ermittelte Leistung, die in der praktischen Züchtung vielfach als Maßstab der Erbveranlagung eines Tieres verwendet wird, miteinander hinsichtlich ihrer Sicherheit zu vergleichen, indem beide Methoden hinsichtlich ihrer Übereinstimmungsgüte mit der Partner-Nachkommen-Methode (Familienleistungsblatt) geprüft werden. Jene der beiden Methoden—Ahnentafel wie Kurzsippentafel—welche nachweislich die bessere statistische Übereinstimmungsgüte zum Ergebnis der Prüfung mit dem Familienleistungsblatt hat, verdient demnach auch in der Züchtungspraxis den Vorzug unter den beiden erstgenannten Methoden.

Das Untersuchungsmaterial wurde 284 Zuchten (Leghorn, Italiener, Rhodeländer und Wyandotten) des deutschen Reichsgeflügelherbuches mit etwa 900 Familienleistungsblättern und 151 Kurzsippentafeln entnommen. Die geringe Zahl der Kurzsippentafeln im Vergleich zu der der Familienleistungsblätter erklärt sich dadurch, daß die Buchungsunterlagen weiter zurückliegender Jahre noch manche Lücken aufwiesen und somit eine vollständige Ausfertigung der Kurzsippentafeln nicht möglich war. Auch die oben erwähnten 151 Kurzsippentafeln konnten nicht alle zu dem Vergleich herangezogen werden. Um zu wirklich folgerichtigen Schlüssen kommen zu können, wurden an das zum Vergleich ausgewählte Material strenge Forderungen gestellt: 1.) Jeweils die beiden nach den drei genannten Methoden zu vergleichenden Hähne mußten ihre Nachkommenschaft unter gleichen Umweltbedingungen hervorgebracht haben; es konnten daher nur Hähne, die innerhalb des gleichen Jahres in der Zucht standen, miteinander verglichen werden. 2.) Die Verteilung der Nachkommen auf die einzelnen Schlupfmonate mußte für beide Hähne annähernd gleich sein. 3.) Der Prozentsatz der gemerzten geschwisterleistungen gegenüber. Ein Vergleich der durchschnittlichen Nachkommenleistung mit der durchschnittlichen Ahnen- + Ahnengeschwisterleistung zeigt, daß in 7 von 11 Fällen der Hahn die bessere Nachkommenleistung aufweist, für den auch die Ahnengeschwisterleistung höher ist. In die Tabelle 1 ist noch die Spalte "Erbwert" des Hahnes aufgenommen worden. Diese ist einfach nach

$$\frac{\text{Mütterdurchschnitt} + \text{Hahnenleistung}}{2} = \text{Töchterdurchschnitt}$$

TABELLE 1.—*Hähne, welche sich hinsichtlich ihrer Erbveranlagung deutlich unterscheiden mit ihrer Nachkommen- und Ahnen- + Ahnengeschwisterleistung*

Zucht	Hahn	Mütter-durch-schn.	Töchter-durchschn.	σ	Anzahl	Erbwert d. Hahnes	Ahnen- + Ahnengeschwis-terdurchschn.	σ	Anzahl
v. Platen	105/36	15,2	12,89 ± 0,354 kg	±2,5021	50	10,58	13,30 ± 0,203 kg	±2,162	113
"	110/36	15,0	14,11 ± 0,321 "	±1,8168	32	13,22	13,50 ± 0,209 "	±2,126	103
Henrici	3223/36	13,3	11,43 ± 0,340 "	±2,4531	50	9,56	11,63 ± 0,242 "	±1,964	66
"	3276/36	13,0	10,37 ± 0,217 "	±1,3872	41	7,74	11,99 ± 0,240 "	±2,105	77
Kaiser	93/34	13,2	10,62 ± 0,305 "	±2,1752	51	7,92	11,99 ± 0,371 "	±2,901	61
"	7612/34	13,6	11,95 ± 0,219 "	±1,8827	74	10,30	11,38 ± 0,334 "	±2,889	75
Kaiser	7522/34	13,6	10,23 ± 0,422 "	±2,3084	30	6,86	12,05 ± 0,321 "	±2,740	73
"	7628/34	13,8	11,89 ± 0,246 "	±2,0854	72	9,98	12,25 ± 0,364 "	±2,935	65
Kaiser	695/35	13,2	9,18 ± 0,217 "	±2,1925	102	5,16	12,65 ± 0,292 "	±2,513	74
"	552/35	13,6	8,03 ± 0,308 "	±2,1994	51	2,46	12,37 ± 0,357 "	±2,837	63
Beyer	1729/36	13,3	10,88 ± 0,142 "	±1,6853	141	8,46	11,31 ± 0,273 "	±2,514	85
"	1551/36	13,4	11,83 ± 0,223 "	±1,8001	65	10,30	12,61 ± 0,242 "	±2,233	85
Beyer	1767/36	12,9	11,25 ± 0,194 "	±1,5764	66	9,60	12,53 ± 0,233 "	±1,938	69
"	1674/36	13,1	10,48 ± 0,221 "	±1,6651	57	7,86	11,76 ± 0,257 "	±2,570	100
Beyer	1771/36	13,2	11,16 ± 0,211 "	±1,7548	69	9,10	12,73 ± 0,257 "	±2,042	63
"	1674/36	13,1	10,48 ± 0,221 "	±1,6651	57	7,86	11,76 ± 0,257 "	±2,570	100
v. Oertzen	4423/35	13,2	10,27 ± 0,367 "	±1,7998	24	7,34	11,95 ± 0,217 "	±1,864	74
"	149/35	9,1	12,17 ± 0,254 "	±1,4148	31	15,24	11,93 ± 0,304 "	±2,253	55
Liebler	8028/36	12,0	10,49 ± 0,393 "	±1,7120	19	8,98	11,59 ± 0,270 "	±2,058	58
"	36/36	13,0	10,40 ± 0,264 "	±1,6704	40	7,80	12,62 ± 0,262 "	±2,142	67
Reitzenstein	6774/34	13,0	9,29 ± 0,457 "	±2,1915	23	5,58	11,55 ± 0,349 "	±2,154	38
"	4361/34	12,2	11,66 ± 0,385 "	±1,8068	22	11,12	11,68 ± 0,365 "	±2,159	35

Tier mußte für beide zu vergleichende Gruppen annähernd derselbe sein. 4.) Unter Berücksichtigung des Mütterdurchschnittes mußten die Nachkommenleistungen größere Differenzen aufweisen, um zu nachweislichen Unterschieden zwischen den Hähnen zu gelangen.

Infolge der notwendig getroffenen Einschränkungen war daher nur für 11 Fälle ein Vergleich zwischen der Bewertung nach der Kurzsippentafel und der Ahnentafel möglich. Tabelle 1 bringt eine Übersicht der Hähne, für welche der Vergleich durchgeführt werden konnte und stellt zugleich die Nachkommenleistungen den Ahnen- + Ahnen- ermittelt worden. Es wurde jeweils für die beiden zu vergleichenden Hähne die Differenz ihres Erbwertes berechnet und mit einem positiven Vorzeichen versehen, wenn ihr Unterschied in der gleichen Richtung lag, wie bei den Ahnen- + Ahnengeschwistern. In Tabelle 2 sind diese für den Erbwert und die Kurzsippentafeln ergebenden Differenzen zusammengestellt und die sich durchschnittlich ergebende Abweichung zwischen der Bewertung nach der Kurzsippentafel und dem Familienleistungsblatt berechnet worden.

Es ergibt sich danach eine durchschnittliche

Abweichung von + 0,06. Dies besagt, daß zwischen der Beurteilung nach der Kurzsippentafel und der tatsächlichen Zuchtbewährung des Hahnes Übereinstimmung besteht und zwar eine sehr gute. Die Abweichung ist nur sehr gering. Der gleiche Vergleich wurde für die Ahnentafel und das Familienleistungsblatt durchgeführt.

TABELLE 2.—*Abweichungen der Kurzsippentafel vom Familienleistungsblatt*

Zucht	Differenz der zu vergleichenden Hähne nach		F.L.B. – K.S.T.
	F.L.B.	K.S.T.	
v. Platen	+2,64	0,19	+2,45
Henrici	−1,82	0,37	−2,19
Kaiser	−2,38	0,61	−2,99
"	+3,12	0,20	+2,92
"	+2,70	0,28	+2,42
Beyer	+1,84	1,30	+0,54
"	+1,74	0,77	+0,97
"	+1,24	0,97	+0,27
v. Oertzen	−7,90	0,02	−7,92
Liebler	−1,18	1,02	−1,20
Reitzenstein	+5,54	0,13	+5,41

TABELLE 3.—*Gegenüberstellung der Ahnenleistung mit den Nachkommenleistungen der zu vergleichenden Hähne*

Zucht	Hahn	Töchter-durchschn.	Ahnen-durchschn.	volle Ahnen-reihen
v. Platen	105/36	12,89	15,58	4
"	110/36	14,11	15,99	4
Henrici	3223/36	11,43	13,38	4
"	3276/36	10,37	13,11	4
Kaiser	93/34	10,62	13,93	3
"	7612/34	11,95	14,07	3
Kaiser	7522/34	10,23	13,78	4
"	7628/34	11,89	14,16	4
Kaiser	695/35	9,18	14,45	3
"	552/35	8,03	14,08	3
Beyer	1729/36	10,88	13,30	4
"	1551/36	11,83	14,03	4
Beyer	1767/36	11,25	13,69	4
"	1674/36	10,48	13,38	4
Beyer	1771/36	11,16	13,89	4
"	1674/36	10,48	13,38	4
v. Oertzen	4423/35	10,27	13,24	4
"	149/35	12,17	14,29	3
Liebler	8028/36	10,49	13,45	3
"	36/36	10,40	14,35	3
Reitzenstein	6774/34	9,29	13,88	3
"	4361/34	11,66	13,41	2

In Tabelle 3 sind die Ahnendurchschnittsleistungen zusammengestellt und wieder den Nachkommenleistungen gegenüber gestellt worden.

Hier weisen in 9 von 11 Fällen die zwischen den einzelnen Hähnen bestehenden Unterschiede beim Töchter- und Ahnendurchschnitt in die gleiche Richtung. Es wurde auch die durchschnittliche Abweichung berechnet und ist aus nachfolgender Tabelle 4 zu ersehen:

TABELLE 4.—*Abweichungen der Ahnentafel vom Familienleistungsblatt*

Zucht	Differenz der zu vergleichenden Hähne nach		F.L.B. – A.T.
	F.L.B.	A.T.	
v. Platen	+2,64	0,41	+2,23
Henrici	+1,82	0,27	+1,55
Kaiser	+2,38	0,14	+2,24
"	+3,12	0,38	+2,74
"	+2,70	0,37	+2,33
Beyer	+1,84	0,73	+1,11
"	+1,74	0,31	+1,43
"	+1,24	0,51	+0,73
v. Oertzen	+7,90	1,05	+6,85
Liebler	−1,18	1,10	−2,28
Reitzenstein	−5,54	0,47	−6,01

Danach ergibt sich die durchschnittliche Abweichung der Bestimmung der Leistungsveranlagung eines Hahnes nach der Ahnentafel von seiner Erbgutschätzung nach dem Partner-Nachkommenvergleich zu + 1,17. Das positive Vorzeichen besagt, daß zwischen der Bewertung nach der Ahnentafel und der tatsächlich erhaltenen Nachkommenleistung eine Übereinstimmung dahin besteht, daß der Hahn mit den besseren Ahnenleistungen auch die besseren Nachkommenleistungen aufweist. Jedoch ist die durchschnittliche Abweichung von dem tatsächlichen Zuchterfolg hier bedeutend höher als bei einer Bewertung nach der Kurzsippentafel (+ 1,17 gegenüber + 0,06). Eine variationsstatistische Sicherstellung dieser Abweichungen ist infolge der geringen Zahl der Fälle leider nicht möglich. Letztere war wieder eine Folge der schon oben erwähnten notwendigen Strenge der gestellten Forderungen. Aus diesen aber sonst einwandfrei durchgeführten Untersuchungen geht hervor, daß von den beiden Methoden—Beurteilung nach der Ahnentafel oder Beurteilung nach der Kurzsippentafel—diejenige nach der Kurzsippentafel den Vorzug verdient, da sie die größere Übereinstimmungsgüte mit dem tatsächlichen Zuchterfolg aufweist und somit bei der Auswahl der Zuchthähne den sichersten Wertmaßstab darstellt; ist doch die richtige Hahnenwahl von sehr großer Bedeutung für den züchterischen Fortschritt.

Es ist beabsichtigt, die Untersuchungen an weiterem Material des deutschen Reichsgeflügelherdbuches fortzusetzen und eine umfassende Arbeit darüber zur Zeit des Weltgeflügelkongresses im Archiv für Geflügelkunde zur Veröffentlichung zu bringen.

ZUSAMMENFASSUNG

Aufgabe der vorliegenden Untersuchungen war es, die 3 Methoden der Erbgutschätzung von Hähnen 1) durch den Partner-Nachkommenvergleich, 2) durch die Ahnentafel, 3) durch die Kurzsippentafel hinsichtlich ihrer Übereinstimmung in Vergleich zu setzen. Da der Partner-Nachkommenvergleich den tatsächlichen Zuchterfolg darstellt, bietet er den sichersten Maßstab. Es wurden daher die aufgrund der Ahnentafel wie auch der Kurzsippentafel ermittelten Leistungen hinsichtlich ihrer Übereinstimmungsgüte mit der Partner-Nachkommenmethode (Familienleistungsblatt) geprüft. Das Unterlagenmaterial wurde dem Deutschen Reichsgeflügelherdbuch entnommen. Von dem zum Vergleich herangezogenen Material wurden gleiche Umweltbedingungen, gleicher Prozentsatz der gemerzten Tiere und größere Differenzen der Nachkommenleistungen gefordert. Infolge dieser für folgerichtige Schlüsse notwendigen Einschränkungen war daher nur für 11 Fälle ein Vergleich zwischen der Bewertung nach der Kurzsippentafel und der Bewertung nach der Ahnentafel möglich. Der Vergleich wurde derart durchgeführt, daß sowohl für die Ahnen- + Ahnengeschwisterleistung (Bewertung nach der Kurzsippentafel) als auch die Ahnenleistung (Bewertung nach der Ahnentafel) die Differenz zwischen den zu vergleichenden Hähnen ermittelt wurde und diese jeweils der sich aufgrund des Familienleistungsblattes gewonnenen Erbwertdifferenz gegenübergestellt wurde. Die Erbwertfeststellung eines Hahnes anhand des Familienleistungsblattes erfolgte nach

$$\frac{\text{Mütterdurchschnitt} + \text{Hahnenleistung}}{2} = \text{Töchterdurchschnitt}$$

Es ergab sich für die durchschnittliche Abweichung zwischen der Bewertung nach der Kurzsippentafel und dem Familienleistungsblatt +0,06, für die durchschnittliche Abweichung zwischen der Bewertung nach der Ahnentafel und dem Familienleistungsblatt +1,17. Daraus folgt, daß die aufgrund der Kurzsippentafel als auch der Ahnentafel für besser befundenen Hähne im Durchschnitt auch die besseren Nachkommenleistungen aufweisen; jedoch ist die durchschnittliche Abweichung von dem tatsächlichen Zuchterfolg für die Ahnentafel bedeutend höher als für die Kurzsippentafel. Letztere zeigt eine sehr hohe Übereinstimmung mit der tatsächlichen Zuchtbewährung eines Hahnes, sodaß sie ohne Zweifel den sichersten wertmaßstab für die Auswahl der Zuchthähne darstellt.

SUMMARY

The present paper is concerned with a comparison of the three methods of evaluating the genotype of cocks: (1) The partner-progeny test, (2) the production of the ancestors, and (3) the production of the sibs.

Since the partner-progeny test represents the actual breeding results, this test offers the most certain measure of the genotype and, therefore, the productions determined from the production of the ancestors as well as from the production of the sibs were tested for fit with the former.

The source of the data was the German National Poultry Pedigree Register. The material to be compared was selected for identical surroundings and for the same percentage number of culled individuals with greater variation in the progeny production. Because of these standards set, necessary for valid conclusions, only 11 cases were available for evaluation according to the production of the ancestors and the production of the sibs. Comparisons were made by first determining the difference between the cocks to be tested against each other according to the production of the sibs as well as according to the production of the ancestors and then comparing this difference with the respective genotypic difference which is based on the family production pedigree.

The determination of the genotype of a cock from a family production pedigree is as follows:

$$\frac{\text{Mean of the dam's production} + \text{sire index of production}}{2} = \text{daughter index}$$

The mean deviation between the evaluation according to the production of the sibs and the family production pedigree was +0.06; the mean deviation between the evaluation according to the production of the ancestors and the family production pedigree was +1.17.

Hence the sires having better standing according to the production of the sibs as well as according to the production of the ancestors on the average also show the better progeny production. However, the mean deviation from the actual breeding results is considerably higher for the production of the ancestors than for the production of the sibs. The latter shows a very high correspondence with the actual progeny production of the sire so there is no doubt that this represents the most certain standard of selection for breeding sires.

HERITABLE BODY SHAPE OF THE DOMESTIC TURKEY

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These researches concerning heritable body shape in turkeys were initiated to determine the value of selective breeding in the production of birds having superior market conformation. Owing to the general increase in buying and selling on a conformation basis, the primary purpose was to evaluate the contribution of heredity as contrasted with environmental conditions of feeding and management. When the environment is uniform, the inheritance of the bird defines the limit of quality. It is only the heritable portion of the variability that constitutes any permanent improvement in the breed.

Body conformation is ordinarily described in a subjective manner, resulting from impressions received through the hands and eyes. Such observations vary with the individual and with previous experiences. To obtain observations based on definite standard units, linear measurements of the body were expressed as a ratio of the cube root of the body weight. These resulting numerically expressed measures of body shape are summarized and, by the use of statistical analysis, their value is predicted.

Since a large number of measurements would be too laborious, a survey was made of the value of eight different linear dimensions from the living bird. This study[1] involved 1,295 turkeys of five different breeds measured between the twenty-seventh and twenty-eighth week after they had been hatched. In this trial, the ratio between the shank length and the cube root of the body weight proved to be superior. In addition, similar ratios involving the anterior body depth and keel length gave added information. As they were used in this trial, other measurements of body depth and width proved to be valueless for selective breeding.

When linear measurements are treated in the manner described, they become valid numerical expressions of body shape. They corroborate those impressions received through the eyes and hands when birds are handled. Proportionally, males have greater anterior body depth and shank length than do females. As expressed by differences between breeds under similar feeding and management, the influence of heredity is best measured by proportional length of shank, anterior body depth, and length of keel. Proportional body weight for a specified shank length is an excellent measure of plumpness of the body and, incidentally, when birds of similar breeding are compared it depicts the apparent fatness or finish of the body for human consumption.

To check these results further with those obtained from the body after the feathers are removed, 132 dressed males and 115 dressed females were measured and graded at a commercial packing plant. The results of these investigations give additional support to the conclusions already stated. In a study reported at the same time,[2] these ratios proved to be equally applicable in expressing numerically the body shape of cockerels and capons at 10 months after hatching. From these and other researches it appears logical to conclude that each race or species of bird is constructed on a rather definite skeletal pattern. The length of the tarsometatarsus (shank) is an index of the skeletal size of the bird. If additional flesh and fat are placed around this previously defined skeletal size, the result is a more rotund body that commands a higher market value when sold for human consumption.

An interesting relation between the termination of growth in length of the shank and cessation of general body growth has been reported.[3] General body growth of turkeys and chickens, when measured by consistent increase in weight or keel length, continues to the end of the tenth month or longer after hatching. Most of the females have attained their maximum shank length by 20 weeks of age, whereas that of the males continues for approximately 4 weeks longer. Considering shank length as a measure of skeletal size, when body shape of a strain is known, hereditary size of the bird may be predicted at 5 months of age in females and at 6 months in males. Since the length of time to which the shank is subjected to fluctuating environment is approximately half of that required for complete growth, its value as a measure of hereditary size is evident.

In cognizance of these facts, a study was made of the hereditary sex difference in actual shank length for the purpose of using both sexes in the study of the progeny of different dams. For this purpose all progenies of dams having fewer than four individuals of one sex were arbitrarily omitted. These records include shank lengths of 511 males and 508 females. In this population there was no overlapping of the shank length of the two sexes. The mean shank length for all

[1] JAAP, R. G. Body conformation of the live market turkey. Poultry Sci. 17:120–125. 1938.

[2] JAAP, R. G., and PENQUITE, R. Criteria of conformation in market poultry. Poultry Sci. 17:425–430. 1938.

[3] JAAP, R. G. Estimating the influence of heredity on the tarso-metatarsal length of the domestic turkey. Okla. Acad. Sci. Proc. 18:11–13. 1938.

birds recorded was 7.57 inches for males and 5.95 inches for females. In a study of the progeny of 37 dams, the shank lengths of males were 27.3 percent greater than those of their full sisters. In a comparison of the adjusted mean length of the shanks of females with that of their brothers, a highly significant fit was demonstrated by the Chi-square method of goodness of fit. As a further check, the correlation between mean shank length of brothers and sisters was found to be 0.72 and is highly significant.

From an analysis of the variance contributed by the sire and the dam, it is noted that the influence of heredity is greater on shank length of the female than on that of the male. This fact may be attributed to the shorter period of time required for completion of shank growth in females. Should it be necessary to adjust the shank lengths of the sexes to similar numerical values for inheritance studies, the shank length of the female should be adjusted to that of the male by multiplying the former by 1.273.

The quantity of flesh on the breast of the bird is of greatest interest to both seller and buyer. The contour of this area probably has more influence on the monetary value of the bird than that of any other region. To locate the best points from which to measure breast width many different possibilities have been tested. The method of location that gives best results, both by agreement with the visual appearance and by the largest numerical difference between visual conformation groups, is briefly as follows. Suspend the freshly killed, plucked, and chilled bird by the legs. Measure the width of the breast from points on each side that are approximately 1½ inches from the anterior point of the keel on a line toward the insertion of the femurs. The reasons for this choice of location have been described by Jaap and Penquite.[4] Owing to a relatively large experimental error, no satisfactory measure of breast width has yet been devised for live birds. The relation between shank length and body weight proved to be much superior for use in breeding studies.

The preliminary population survey demonstrated that at 28 weeks of age breeds of turkeys reared under the same feeding and management vary in proportional body shape. To test the influence of heredity within a breed, superior and inferior conformation selections are being made in the Narragansett variety. The aim in these selections is to keep the adult weight approximately the same in both lines. In the superior selections, birds approaching the ideal market quality are chosen as parents. The age at which market quality is determined is 24 weeks for females and 28 weeks for males. These ages correspond to approximately 4 weeks after the shank has ceased growth in length. Angular-bodied birds are used to perpetuate the inferior selections. Each parent is selected entirely from the measurements taken at the ages specified. Personal opinion is eliminated as far as possible. For this report, the first-year selection records only are available.

Since turkeys are marketed before they have reached the end of their growth period, periodic weights were taken from the twelfth week until the fifty-second week after hatching. These were recorded at 12, 16, 20, 24 weeks, and every 2 weeks thereafter. By the use of the criteria of conformation that have been discussed, during the first year the superior selection has consistently maintained plumper bodies throughout this growth period.

In table 1 are presented mean data for age at first egg of the females and maximum first-year measurements of both sexes. It will be observed that the female progeny of the superior selection obtained maximum body weight approximately 4½ weeks younger than those from the inferior mating. An interesting relation is noted between age at maximum body weight and age at first egg. In both selection lines the former precedes the latter by about 1 week.

TABLE 1.—*Mean data for the adult progeny resulting from the superior and inferior parent selection*

Type of parent selection	Sex of progeny	Birds	Mean age at— Maximum body weight	Mean age at— First egg	Mean body weight	Maximum first-year measurement of— Shank length	Keel length	Anterior depth
		Number	*Weeks*	*Weeks*	*Pounds*	*Inches*	*Inches*	*Inches*
Superior	Female	26	42.1	43.3	15.42	5.91	6.29	7.14
Inferior	Female	44	46.7	47.7	15.01	6.02	6.29	7.47
Superior	Male	26	48	....	29.06	7.57	8.79	10.40
Inferior	Male	29	48	....	27.70	7.59	8.34	10.40

SUMMARY

To study the influence of heredity on the conformation of the domestic turkey at market age, linear measurements are expressed as a ratio of the cube root of the body weight. Of eight different measurements used, three giving superior and consistent results are shank length, anterior

[4] See footnote 2.

body depth, and keel length. For these three measurements a relatively high correlation is obtained between values for live and dressed birds.

The female shank reaches its mature length between the twentieth and twenty-second week after hatching, whereas the male shank requires approximately 4 more weeks to complete its growth in length. The same is true for the domestic chicken. General body growth, when measured by increase in keel length or consistent increase in body weight, continues until 42 to 48 weeks. The mature shank of the turkey male is 27.3 percent longer than that of the female. Heredity has greater influence on female shank length, probably resulting from a shorter period of growth.

Selections of superior (plump) and inferior (thin, angular) parents from measurement data produce offspring that differ in body shape from the twelfth to the fifty-second week after hatching. Progeny of the superior selection have proportionally shorter shanks and proportionally less body depth at all ages measured. Female progeny from the superior selection reach maximum body weight approximately 4½ weeks prior to those of the inferior selection. Mean age at first egg occurs about 1 week after greatest first-year weight is attained.

ABSENCE OF LINKAGE BETWEEN GENES FOR EARLY SEXUAL MATURITY AND GENES FOR HIGH PERSISTENCY IN EGG PRODUCTION IN THE DOMESTIC FOWL

By F. A. Hays, *Research Professor in Poultry Investigations, Massachusetts State College, Amherst, Massachusetts, U. S. A.*

Hays (1927) suggested a possible linkage relation between autosomal gene E′ and gene P for high persistency in egg production because most early maturing birds were highly persistent and most late maturing birds were nonpersistent. It was suggested at that time that high persistency was governed by one dominant autosomal gene. Hays and Sanborn (1933) reported the simple correlation between age at first egg and length of biological year to be −0.5661 ± 0.0152 with linear regression. Hays (1936) presented further evidence to indicate that high persistency is governed by a single dominant autosomal gene. Knox, Jull, and Quinn (1935) studied some of the different measures of persistency and suggested a possible spurious relationship between sexual maturity and persistency. Lerner and Taylor (1937a) showed statistically that the correlation between sexual maturity and length of the biological year is spurious. Lerner and Taylor (1937b) have shown that age at the end of the biological year, instead of length of the biological year, may be used as a measure of persistency.

The studies reported here are based on the same group of 911 Rhode Island Reds reported on by Hays and Sanborn (1933). This report is an effort to show statistically that the correlation between age at first egg and length of biological year is spurious and to show why no linkage exists between the gene E′ for early sexual maturity and gene P for high persistency. Even though there is a spurious correlation between age at sexual maturity and duration of the biological year, there is no evidence against the inheritance of the ability to lay for a long period before the onset of annual molt.

	Simple correlations
Age at first egg and length of biological year	−0.5651 ±0.0152
Age at first egg and annual persistency	−0.4632 ±0.0176
Age at first egg and age at last egg within 365 days	+0.1239 ±0.0220
Age at first egg and age at last egg of biological year	−0.0654 ±0.0223
Age at last egg of biological year and length of biological year	+0.8656 ±0.0056
Age at first egg and annual production	−0.3213 ±0.0200
Length of biological year and annual production	+0.5520 ±0.0155

Since length of the biological year equals age at last egg (l) minus age at first egg (f), then since l and f are not correlated ($r = -0.0654 \pm 0.0223$), the correlation between f and length of biological year ($r = -0.5651 \pm 0.0152$) is spurious. The above relationships account mathematically for the high correlation existing between age at first egg and duration of the biological year.

A study of the regression of age at last egg of the biological year on age at first egg showed a linear relationship in these data. Although the value of the coefficient of correlation indicated an insignificant relationship, the actual age of the early maturing birds was about 25 days greater at last egg than that of the late maturing birds. In other words, there was a very close approach to a significant negative correlation between age at first and last eggs of the biological year.

Attention may next be given to evidence against linkage between the autosomal gene E′ for early sexual maturity and gene P for high persistency. Sex-linked gene E for early sexual maturity need not be considered here because there is no evidence of sex-linked genes governing persistency.

The birds used in this study represent a specially selected group made up of the most promising individuals for breeders at the close of each first laying year. The sample was made up almost entirely of early maturing and highly persistent individuals. Table 1 shows no consistent change since 1920 either in mean age or in mean length of the biological year. These birds differ greatly from the flock as a whole, which showed consistent progress in increasing the length of the laying year through this period.

A detailed study of the ranges in age at first egg and age at last egg of the biological year, considering both the early maturing genotypes (E E′, E e′, and e E′) and the late genotype (e o e′ e′) together with the persistent (PP and Pp) and the nonpersistent (pp) genotypes, brought forth some important information. These studies, the results of which follow, are based on 911 Rhode Island Red females.

TABLE 1.—*Mean age of birds at first egg and mean length of biological year*

Year in which birds were hatched[1]	Age of birds at first egg		Length of biological year	
	Birds	Mean age	Birds	Mean length
	Number	*Days*	*Number*	*Days*
1917	118	207.05	118	326.64
1920	40	192.63	40	373.90
1921	46	200.02	46	348.04
1922	133	185.53	133	368.59
1923	74	198.43	74	361.86
1924	44	187.11	44	375.08
1925	115	182.44	115	360.82
1926	69	183.14	69	371.86
1927	75	182.31	75	374.45
1928	89	191.39	89	381.27
1929	71	188.41	71	373.32
1930	37	187.03	37	371.14

[1] Birds were not carried through 1918 and 1919 because of disease.

Total range for age at first egg, 140 to 319 days, a difference of 179 days.
Possible range for age at first egg in early maturing group, 140 to 215 days, a difference of 75 days.
Possible range for age at first egg in late maturing group, 216 to 319 days, a difference of 103 days.
Total range for age at last egg, 390 to 679 days, a difference of 289 days.
Possible range for highly persistent birds, 410 to 679 days, a difference of 269 days.
Possible range for nonpersistent birds, 390 to 588 days, a difference of 198 days.
Possible range in age at last egg of highly persistent birds in early maturing class, 410 to 679 days, a difference of 269 days.
Possible range in age at last egg of highly persistent birds in late maturing class, 486 to 679 days, a difference of 193 days.
Possible range in age at last egg of nonpersistent birds in early maturing class, 390 to 484 days, a difference of 94 days.
Possible range in age at last egg of nonpersistent birds in late maturing class, 390 to 588 days, a difference of 198 days.

In the population studied, the odds in favor of a bird being early maturing were $\frac{824}{911}$ and the odds in favor of a bird being highly persistent were $\frac{892}{911}$. On this basis, the probability of a bird being both early maturing and highly persistent was 0.88. Such odds indicate that the program of breeding for early sexual maturity and high persistency has been effective.

As has already been shown, there is no significant correlation between age at first egg and age at last egg of the biological year. This fact indicates mathematically that the observed negative correlation between age at first egg and length of the biological laying year is spurious. Since the correlation between sexual maturity and duration of the biological laying year is spurious, the assumption is that no linkage exists between genes for early sexual maturity and genes for high persistency.

Assuming that the most frequent type of mating to produce the 911 birds through the years was Ee E′ e′ males × Eo E′ e′ females, the expectation would be seven-eighths early maturing to one-eighth late maturing, or 798 to 114. The actual ratio was 824 early maturing to 87 late maturing. The actual agrees rather closely with the expected ratio. In the total population, one-eighth should be early maturing because of gene E alone and six-eighths should be early maturing because of gene E with E′ or gene E′ alone. If gene P is linked with gene E′, six-eighths of the 911 birds should be early maturing and persistent. The calculation was 683 early maturing and persistent, 114 early maturing and nonpersistent, and 114 late maturing. The actual data showed 821 early maturing and persistent, 3 early maturing and nonpersistent, and 87 late maturing, of which 71 were highly persistent and 16 nonpersistent. These data furnish no evidence of linkage between the sexual maturity gene E′ and persistency gene P. The significant fact has also been observed that no early maturing families occurred in which all individuals lack high persistency, as would be the case in families carrying sex-linked gene E only.

A crucial test for the absence of linkage between autosomal gene E and autosomal gene P could be made in a line of birds known to lack the sex-linked gene E for early sexual maturity but carrying gene E′. Such a line is now being developed by the use of a sex-linked gene as a marker.

SUMMARY

A study of possible linkage between genes for early sexual maturity and genes affecting length of the biological laying year was made on 911

Rhode Island Red females hatched from 1917 to 1930. The spurious correlation between age at sexual maturity and length of the biological year reported by Lerner and Taylor (1937a) in Leghorns was found to occur in Rhode Island Reds. The data further indicate independent inheritance of genes for early sexual maturity and genes for high persistency. No evidence appeared against the expediency of selecting breeding stock on the basis of length of biological year.

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VERERBUNG DER AUGENFARBE BEI HÜHNERN

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Den Mittelpunkt des Auges bildet das schwarze Sehloch, die Pupille, die beim Huhn kreisrund sein soll. Der Pupillenrand soll scharf abgesetzt sein gegen den ihn umgebenden breiten farbigen Ring, die Iris oder Regenbogenhaut. Diese Regenbogenhaut ist bei den weitaus meisten Hühnerrassen gelbrot oder orangerot. Die wenigen Rassen, für die der Standard hiervon abweichende Augenfarbe vorschreibt, spielen wirtschaftlich kaum eine Rolle. Die folgende Arbeit beschränkt sich auf die Untersuchungen der Veränderungen, die die Augenfarbe von Hühnern mit gelbroten bezw. orangeroten Augen erleidet, sie sind an weißen Leghorn, rebhuhnfarbigen Italienern und roten Rhodeländern durchgeführt. Um die Frage der Vererbung der Augenfarbe prüfen zu können, sind erst Beobachtungen der auftretenden Veränderungen erforderlich. Die Untersuchungen werden an einem Bestand durchgeführt, in dem häufig Augenveränderungen beobachtet wurden. Sie begannen im Januar 1938 und sind im Zeitpunkt der Niederschrift dieses Berichtes noch nicht abgeschlossen.

Für den Versuch diente in erster Linie eine Gruppe von 747 Jungtieren, die alle mit Kückenmarken einzeln gekennzeichnet waren und von Elterntieren mit gelbroten bezw. orangeroten Augen abstammen. Die Augen der Kücken waren einheitlich blaugrau, schmutziggrau, Pupille und Iris waren nicht zu unterscheiden.

Im Alter von 12 Wochen wurden diese Kücken beringt. Auch zu diesem Zeitpunkt war die Pupille noch nicht scharf gegen die Iris abgesetzt, bei einem Teil der Tiere war die Pupille beiderseits geradezu unrund. Um die Pupille zog sich bei der Mehrzahl der Tiere noch ein grauer Ring. Die Regenbogenhaut war graugelb, grüngelb, zum Teil trüb. Vor allem bei zurückgebliebenen Tieren war die Iris noch grau oder gar blaugrau. Nur einzelne Tiere hatten bereits gelbe, ganz vereinzelte schon hellorangefarbene Augen. Es geht daraus hervor, daß die Einfärbung des Auges sich bei den verschiedenen Tieren nicht ganz gleichmäßig vollzieht. Allgemein ist festzustellen, daß sich das Kückenauge über graugrün zu graugelb—hellgelb—gelb—gelbrot—orangerot—und rot verfärbt. Im Entwicklungsalter wurden alle Übergänge dieser Farbenskala angetroffen. Die Iris ist dabei zum Teil klar, zum Teil trüb. Von den Augen der 747 beobachteten 12 Wochen alten Junghennen wurden bezeichnet als:

	Tiere	Prozent
Grün bis grüngrau	225	30
grau bis graugelb	125	17
trübgrau bis trübgelb	124	17
gelb bis orangegelb	254	33
orangerot	19	3

Allgemein kann gesagt werden, daß im Alter von 12 Wochen die Einfärbung der Iris um so weiter vorgeschritten ist, je kräftiger das betreffende Tier entwickelt ist.

Die nächste Untersuchunge der Augen dieser Jungtiere wurde anläßlich der Blutentnahme zur Untersuchunge auf Bakterium Pullorum vorgenommen. Zu diesem Termin, im September 1938 waren die Tiere nun nicht mehr wie bei der Beringung gleich alt, das Alter schwankte zwischen $4\frac{1}{2}$ und $6\frac{1}{2}$ Monaten. Bei dieser Untersuchung zeigten nur 1,2 Prozent aller Tiere noch trübgelbe Färbung der Regenbogenhaut, sämtliche übrigen Tiere hatten gelborange bis dunkel rotorange gefärbte Augen.

Die dritte Gesamtuntersuchung fand anfangs Februar 1939 statt, die Tiere waren nunmehr 9 und 11 Monate alt. Hier ergab sich nun ein ganz anderes Bild. Bei einem Teil der Tiere hellte die Iris wieder auf, bei einem Teil verfärbte oder entfärbte sie sich und zwar auf zweierlei Weise: (1) Es bildet sich rund um die Pupille ein anfangs kaum auffallender hellerer Ring. Der Ring nimmt dann an Breite immer mehr zu, wobei der innere gegen die Pupille zu liegende Rand des Ringes heller ist als der äußere Rand. Der Ring breitet sich immer mehr aus bis zur vollen Entfärbung der Regenbogenhaut. (2) Es ist kein Ring wahrzunehmen, sondern die Entfärbung erfolgt strahlenartig, wobei mit fortschreitender Aufhellung die Strahlen breiter werden, bis sie sich gegenseitig berühren und so die ganze Iris entfärben. Die Regenbogenhaut bleibt nun entweder wässerig hell, entfärbt, oder sie nimmt den leblosen Ausdruck eines Fischauges an, sie verfärbt sich. Bei einzelnen Fischaugen beginnt dann die bisher scharfumrandete glänzend schwarze Pupille leblos zu werden, der Pupillenrand scheint zu verlaufen, er wird unscharf, die Pupille wird unrund. Im weiteren Verlauf erblindet das Tier meist.

Unter den Tieren, die zu diesem Termin, Anfang Februar noch die bestgefärbten Augen hatten, war eine Anzahl stark zurückgebliebener Tiere. Bei den Tieren mit entfärbtem oder verfärbtem Auge befanden sich gute und schlechte Leger. Von den ursprünglich untersuchten Tieren konnten bei dieser Untersuchung nicht alle erfaßt werden, es wurden 445 Junghennen beobachtet deren Augenfarbe folgende Verteilung aufweist:

	Tiere	Prozent
Orangegelb	301	67
heller Ring	59	13
aufhellende Iris	25	6
entfärbte Iris	34	8
Fischauge	26	6

Ein Teil der zu diesen Untersuchungen herangezogenen Junghennen, insgesamt 120 Tiere aus Aprilschlupf, wurden in einer geschlossenen Gruppe gehalten, diese Tiere konnten so zwischen den allgemeinen Untersuchungsterminen beobachtet werden. Von diesen Tieren hatten bereits am 3.12.1938 27 Prozent die Augenfarbe leicht verändert, bei der Untersuchunge Anfang Februar 38 Prozent. Es kann daraus der Schluß gezogen werden, daß das Ausblassen der Augen erst nach dem 7. Lebensmonat beginnt und dann bei hierzu veranlagten Tieren rasch vor sich geht.

Die Beobachtungen erstreckten sich weiter auf die Hähne des Betriebes, soweit diese als Zuchthähne beringt wurden. Der Verlauf der Einfärbung der Augen war der gleiche wie bei den Junghennen, die orangegelbe Färbung der Iris trat etwas früher ein als bei den Hennen. Bei der Beringung, also im Alter von 12 Wochen, hatten von 539 Hähnen

	Hähne	Prozent
grün bis grüngraue Augen	101	19
grau bis graugelbe Augen	80	15
trübgelbe Augen	68	12
gelbe bis orangegelbe Augen	257	48
orangerote Augen	33	6

Zwischenbeobachtungen wurden bei 160 Versuchshähnen aus Märzschlupf nach dem Beringen in 14 tägigen Abständen gemacht, die zeigten, daß die Einfärbung wie bei den Hennen vor sich geht. Im Alter von $4\frac{1}{2}$ Monaten war die Augenfarbe durchweg orangegelb bis orangerot, nur einige zurückgebliebene Hähnchen hatten grünliche Iris.

Die Annahme, daß entsprechend der rascheren Einfärbung bei Hähnen auch die Aufhellung früher beginnen würde, hat sich bei der Beobachtung im September anläßlich der Blutentnahme bestätigt. Es wurden die Augen von 8 Prozent aller Hähne als aufgehellt bezeichnet gegenüber 1,2 Prozent bei den Junghennen. Bei der ein Monat später durchgeführten Körung wurden die Augen von fast der Hälfte aller Hähne als in Entfärbung begriffen bezeichnet. Der Aufhellungsprozeß verläuft wie bei den Junghennen ringförmig oder strahlenförmig. Anfangs Februar hatte keiner der im Betrieb verbliebenen Hähne mehr ausgesprochen rote Augen wie man sie bei Hähnen wünscht. 2/3 der Hähne besaßen noch orangegelb gefärbte Regenbogenhaut, vom dritten Drittel war die Mehrzahl entfärbt, einige Hähne zeigten Fischaugen.

Die Untersuchungen erstreckten sich ferner auf 120 Alttiere, die im Januar 1938 in die Herdbuchstämme eingestellt wurden und zu diesem Zeitpunkt kräftig orangegelbe bis rote Färbung der Iris zeigten. Bei der Auflösung der Stämme Ende April 1938 war bei 9 der Hennen ein heller Ring um die Pupille zu beobachten, der Rest dieser Tiere hatte gelbe Iris. Am 9.12. wurden die Tiere wieder beurteilt, sie standen in der Mehrzahl in der Mauser. 8 Tiere hatten zu diesem Zeitpunkt den hellen Ring um die Pupille, bei 12 Tieren war die Iris entfärbt.

Zur Untersuchung wurden weiterhin die bei der Bayerischen Leistungsprüfung für Hühnerstämme stehenden 182 Hennen herangezogen. Die Prüfung begann am 16.10.38, die Tiere waren zu diesem Zeitpunkt etwa 7 Monate alt. In Abständen von 2 Monaten wurden sie bezüglich der Augenfarbe untersucht. Bei Beginn der Prüfung hatten von den 182 Tieren

	Tiere	Prozent
orangerote Augen	152	84
orangegelbe Augen	24	13
gelbe Augen	6	3

Die Augen waren somit als recht gut und ausgeglichen zu bezeichnen, obwohl die Tiere der 26 Stämme 24 verschiedenen Züchtern gehören. Die Augen der Tiere, die noch bei Beginn der Prüfung gelbe Iris besaßen, dunkelten in den nächsten Wochen noch nach.

Bei der Beurteilung am 15.12.38 war eine allgemeine leichte Aufhellung zu beobachten. Von den Tieren hatten

	Stück	Prozent
orangerote Augen	72	41
orangegelbe Augen	86	48
gelbe Augen	13	7
entfärbte Augen	7	4

Die nächste Beobachtung Anfang Februar 1939 ergab folgendes Bild:

	Tiere	Prozent
orangerote Augen	32	18
orangegelbe Augen	74	43
gelbe Augen	38	22
entfärbte Augen	29	16,5
Fischaugen	1	0,5

Von den 30 Tieren mit entfärbten oder Fischaugen gehören 14 Tiere 3 Stämmen an, in denen somit 66 Prozent Augenveränderungen auftreten, zwei dieser drei Stämme kommen aus ein und derselben Zucht. Unter den 26 Stämmen der Prüfung befinden sich 12 Stämme, in denen noch keinerlei Augenveränderungen auftreten.

Im Jahre 1938 wurde in Erding ein kleiner Stamm von Tieren zusammengestellt mit ausgesprochen entfärbten grauen Augen. Sie wurden gepaart mit einem Hahn mit Fischauge. Die Einfärbung der Augen der Nachkommen dieser Tiere verlief völlig normal, beim Beringen, also im Alter von 12 Wochen, hatte es den Anscheim als würden sich die Nachkommen dieser grauäugigen Tiere in keiner Weise von den Nachkommen anderer Tiere mit roten Augen unterscheiden. Auch im Zeitpunkt der Blutentnahme, im September, hatten die Junghennen dieses Versuchsstammes noch normale Augen, während die Hähne schon als grauäugig bezeichnet werden mußten. Mitte Oktober hatten die Hähne bereits durchweg Fischaugen. Am 3.12. war die Hälfte der Junghennen aus dieser Versuchsgruppe noch rotäugig, am 3.2. waren die Augen sämtlicher Nachkommen der grauäugigen Tiere völlig entfärbt, fast die Hälfte der Tiere besaß Fischaugen.

Die vorliegenden Untersuchungen haben folgende Tatsachen ergeben:

1. Die Entwicklung der Augenfarbe der Kücken ist etwa im siebten Lebensmonat abgeschlossen. In diesem Alter hatten alle untersuchten Tiere gelb oder orangegelb oder aber orangerot gefärbte Augen, auch die Nachkommen von Tieren mit blassen Augen.

2. Vom siebten Monat an ist bei allen Tieren ein leichtes Abblassen der Regenbogenhaut zu beobachten, das bei gutlegenden Tieren vermutlich schneller und stärker verläuft als bei Nichtlegern. Diese Erscheinung ist nicht mit der Entfärbung oder Verfärbung zu verwechseln.

3. Die Entfärbung verläuft ringförmig oder strahlenförmig, sie beginnt bei hierzu veranlagten Tieren meist im siebten Monat. Entfärbung ist oft auch bei Nachkommen rotäugiger Tiere zu beobachten.

4. Bei Tieren die väterlicher und mütterlicherseits von grauäugigen Tieren abstammen, wurde im siebten Monat beginnend eine rasche und völlige Entfärbung der Augen, vielfach auch eine Verfärbung (Fischauge) beobachtet.

5. Auch bei Tieren die am Ende ihres ersten Legejahres, im Alter von etwa 18 Monaten, noch rote Augen besitzen kann später noch eine Entfärbung auftreten. Diese Entfärbung der Augen älterer Tiere wurde aber nur bei einem kleinen Prozentsatz aller Tiere beobachtet.

6. Fälle von Wiederrotfärbung von nach dem siebten Monat entfärbten oder verfärbten Augen wurden bisher nicht beobachtet.

7. Offen ist noch die Frage ob es sich bei der Entfärbung der Augen nur um einen ererbten Schönheitsfehler handelt, oder um einen konstitutionellen Mangel, oder um die Begleiterscheinung einer Krankheit. Die Untersuchung soll in der Weise fortgeführt werden, daß die anteiligen Verluste unter den Tieren mit guten Augen und unter den Tieren mit entfärbten Augen sowie die Todesursachen bei beiden Gruppen ermittelt werden.

8. Geprüft zu werden verdient ferner die Frage ob die Entfärbung durch Haltungsmaßnahmen zu verhindern ist und ob Wechselbeziehungen bestehen zwischen der Augenfarbe und der Legeleistung. Die Frage nach Wechselbeziehungen zwischen Verzerrung der Pupille und Krankheiten ist hier nicht berührt.

Der mühevollen Arbeit der Sammlung der Unterlagen für diesen Bericht unterzog sich mein Mitarbeiter Dr. Mantel, dessen Verdienst um diese Arbeit hier gewürdigt werden soll.

ZUSAMMENFASSUNG

An einer größeren Zahl von Tieren (Leghorn, Italiener und Rhodeländer) wurde die Entwicklung der Augenfarbe beobachtet und festgestellt, daß die Einfärbung der Kückenaugen im allgemeinen im siebten Monat beendet ist. Dann beginnt ein leichtes Abblassen von orange zu gelb, vor allem bei stark legenden Tieren. Auch die Nachkommen grauäugiger Leghorn verhalten sich bis zu diesem Zeitpunkt ebenso, in den folgenden Monaten verfärben sich die Augen solcher Tiere aber völlig. Aber auch bei Nachkommen rotäugiger Tiere kann eine Entfärbung nach dem siebten Monat eintreten. Tiere die am Ende ihres ersten Legejahres, also im Alter von 18 Monaten noch orangerote Augen besitzen, können später noch Augenentfärbungen erleiden. Dieser Fall tritt aber nicht häufig auf. Fälle von Rotfärbung nach dem siebten Monat entfärbter Augen wurden bisher nicht beobachtet.

Züchter die Wert auf gute Augenfarbe ihrer Herde legen, werden somit gut tun, nicht mit Jungtieren zu züchten, sondern alte Tiere zur Zucht zu verwenden, die sich rote Augen erhalten haben. Eine Gewähr, daß die Nachkommen solcher Tiere einwandfrei gefärbte Augen auf die Dauer behalten, ist allerdings nicht gegeben.

SUMMARY

The development of the color of the eyes was observed in a large number of fowls (Leghorns, Italian fowl, and Rhode Island Reds), and it was found that the coloring of the eyes of chickens is generally completed at 7 months of age. After that time a slight paling from orange to yellow

takes place, particularly with good layers. The behavior of the progeny of gray-eyed Leghorns was the same up to that time, but during the following months, the color of the eyes of such birds faded completely. Even in the offspring of red-eyed birds a change in the color of the eyes could be observed after the seventh month. Discoloring of the eyes may occur at a later date in birds still having orange-red eyes after their first year of laying or at the age of 18 months. This does not happen frequently, however. Cases of reappearance of the red color in discolored eyes after the seventh month have not been observed so far.

Breeders preferring a good color of the eyes of their flock will do well not to use young birds for breeding, but old ones which retained the red color of their eyes. There is no certainty, however, that the progeny of such animals with perfectly colored eyes will retain this color permanently.

PRESENT STATUS OF POULTRY PHYSIOLOGY

By T. C. Byerly, *Professor of Poultry Husbandry, University of Maryland, College Park, Maryland, U. S. A.*

The program of the Physiology Section typifies the fundamental advances that have been made during the last few years in the knowledge of function in the domestic fowl. Physiological research has had practical application in the fields of artificial insemination, utilization of vitamins by the embryo, utilization of the chorio-allantois of the living embryo as a culture medium for pathogens, and the control of egg production. Sound fundamental knowledge of the role of the hormones of the pituitary and of the gonads in sexual maturity, in the development of the secondary sexual apparatus, of sexual behavior, and of sex itself has been gained. New techniques have been developed and applied to the study of the physiology of the expression of genes. Fundamental research and techniques point the way to further research that may eventually make possible a considerable amount of control of growth rate, size, sexual maturity, rate and quality of egg production, disease susceptibility, and many other factors of practical importance to the poultry industry.

Research during the last decade has revealed a great sensitivity of the developing embryo to vitamins and trace mineral deficiencies reflecting similar deficiencies in the diet of the breeding flock. Rickets of embryos in eggs deficient in vitamin D, failure of the yolk sac in vitamin E deficiency, and nutritional micromelia caused by manganese deficiency are now well known. Malformations caused by excessive selenium in feeds have been extensively studied. Hatchability has probably increased 5 percent in the last 5 years owing to the work of nutrition chemists and physiologists. A further possible increase of 20 to 25 percent is a challenge to further effort.

Researches on the development of sex, especially with the use of the sex hormones, has revealed a great lability of chromosomal sexuality in the domestic fowl. Complete reversal with consequent sexually normal individuals is still to be accomplished.

Studies of the effects of the host on feather pigmentation and morphology and of hormones, growth rates, and thresholds in growing feathers in situ on birds of various sexual conditions have yielded fundamental knowledge of the mechanism of genetic expression. Of greater importance, these researches promise to yield techniques for the study of other genetic mechanisms and physiological processes.

Genetic differences in rate of growth have been established. Evidence has been adduced that differences in sulfhydryl at early stages of development characterize strains genetically differing in size. The origin of these differences and their significance remain to be demonstrated. That they are causally related to genetic differences in rate of cell division has by no means been established.

Use of allometry in the study of growth of the fowl has disclosed many mathematical relationships between the growth of parts and of the whole. Is there a fundamental mechanism of partition of nutrients among the parts? Genetically different efficiencies in utilization of nutrients are known to exist. What is the physiological mechanism through which they are expressed?

Studies of the circulating substances touch every other field of physiology. When and in what manner does the defense mechanism against invading organisms and foreign proteins arise? The living embryo's defenselessness against these agents has the practical virtue of making it an ideal culture medium for many pathogens otherwise difficult of culture.

Apparently there are genetic differences in the time of appearance of a defense mechanism capable of combating the pullorum organism which form the basis for the inheritance of resistance to this disease. Will physiological studies disclose similar inherited differences with respect to neurolymphomatosis?

Studies of the agglutinins of pigeons and chickens and of their inheritance are pertinent not only to the defense mechanism but also to the physiology of genic expression as well.

Studies of blood calcium, phosphorus, and lipins are filling the existing gap in the knowledge of the transfer and transformation of nutrient materials into eggs and body structures.

Injection studies with various hormone preparations of pituitary origin indicate that sexual maturity of the male is readily accomplished even in juvenile stages through administration of the follicle-stimulating hormone. The female is relatively refractory to these preparations until about the time of her normal maturity. Maturity may be hastened in sluggish females through exposure to increased periods of illumination. This in turn has been shown to be due to direct stimulation of the pituitary.

Research on many phases of ovulation is abundant. Demonstration of the causal factors in ovulation has been expected for several years. Why is this problem so difficult to solve in the fowl?

Resection studies on the oviduct and histological and chemical studies of the secreting mechanism and of the secretions have established the fundamental role of mucin secretion in determining interior egg quality. Better techniques for measuring interior egg quality and for interpreting candling appearance must be developed before these researches can be given extensive practical application.

Sexual behavior has been shown to be argely under control of the male hormone, even in the female. The bird with the highest level of male hormone is the dominant bird in the flock in general. Broodiness is normally associated with increase in the prolactin content of the pituitary but may be induced without apparent change in the concentration of prolactin. Changes in the blood picture of the broody hen are to be reported at this meeting. Do the various mechanisms capable of eliciting or suppressing broodiness affect the blood picture directly?

Development of the American method of artificial insemination is widely appreciated. Diluents must be developed in which sperm will remain viable for sufficient periods of time for transportation over long distances.

This introductory statement to the program of the Physiological Section includes only a few of the recent accomplishments in the study of the physiology of the domestic fowl. The questions raised may soon be answered or be replaced by problems of greater importance.

Many workers in universities, research foundations, and experiment stations in every part of the world have contributed to our present knowledge and are now engaged in increasing that knowledge.

ARTIFICIAL INSEMINATION OF CHICKENS WITH SEMEN DILUTED IN RINGER SOLUTION

By G. Bonnier *and* Sally Trulsson, *Animal Breeding Institute, Wiad, Eldtomta, Sweden*

In a foregoing paper by Bonnier and Trulsson (1938), some experiments on artificial insemination in poultry were reported. These experiments gave only a low percentage of fertilization (35.4), probably due to inexperience. In the present paper new data are presented. The collection of semen was made by a technique conforming with that described by Quinn and Burrows (1936) and Burrows and Quinn (1937). The practical work was performed by one of us (Trulsson), with an assistant in the poultry house. In these experiments, which began on January 17, 1938, and lasted until May 29 the hens were divided into groups 1 and 2. Group 1 consisted of 4 hens hatched during the spring of 1935, 38 hens hatched during the spring of 1936, and 100 hens hatched during the spring of 1937. Group 2 consisted of 115 hens hatched during the spring of 1937. The hens in the latter group were somewhat younger, on an average, than the group 1 hens born in 1937. In the following presentation the hens of group 1 hatched in 1935 and 1936 are classified together. All hens were crossbred either from a White Leghorn sire and a White Wyandotte dam or from a Rhode Island Red sire and a White Wyandotte dam. The birds from which semen was taken consisted of 30 White Leghorn cocks, and on those days when insemination was performed it was made twice daily, the first insemination being at about 11.30 a.m. and the second at about 5 p.m. The semen collected in the forenoon was from 15 cocks and was thoroughly mixed, and that collected in the afternoon was from the remaining 15 cocks and was also thoroughly mixed. The inseminations were always performed as soon as possible after sperm collection, i.e., within a maximum time of about 1 hour from collecting from the first cock to inseminating the last hen.

From January 17 to March 12 of the experiments the inseminations were made 4 days weekly (Monday, Tuesday, Wednesday, and Friday); from March 13 to May 15, 5 days weekly (the foregoing days and Saturdays); and from May 16 to May 29, daily. However, not all hens were inseminated every day of insemination. On each day of insemination the hens were collected from the trap nests, and thus only those hens which had laid eggs on that day were inseminated. In this way the hens were disturbed as little as

TABLE 1.—*Periods of insemination and sperm concentrations used*

Group 1 (142 hens) Period of insemination	Sperm concentration[1]	Group 2 (115 hens) Period of insemination	Sperm concentration[1]	Remarks
Jan. 17–Feb. 12	30	Jan. 17–Feb. 12	100	....
Feb. 13–Feb. 19	10	Feb. 13–Feb. 19	30	Transitional periods.
Feb. 20–Apr. 23	10	Feb. 20–Mar. 26	30	....
Apr. 24–Apr. 30	2	Mar. 27–Apr. 2	2	Transitional periods.
May 1–May 15	2	Apr. 3–Apr. 23	2	....
May 16–May 22	10	Apr. 24–Apr. 30	10	Transitional periods.
May 23–May 29	10	May 1–May 29	10	....

[1] Expressed as percentage of semen.

possible, and as some eggs were laid 1 day after insemination, others not earlier than 2 days after insemination, others 3 days later, etc., a study could be made of the effect, on fertilization, of time between insemination and egg laying.

After the semen was collected, it was given either undiluted or diluted in a modification of Ringer solution. Its composition was as follows, according to Benzinger and Krebf (1933). In 10,000 cc of water were dissolved:

	grams
Na Cl	68.00
K Cl	17.33
Ca Cl_2	6.42
Mg SO_4	2.50
Na HCO_3	24.50

Each ingredient was dissolved separately in water, and the prepared solution was kept cold. The concentrations of sperm suspensions which were used were 100, 30, 10, and 2 (expressed as percentages of semen). Each hen was given 0.05 cc of the fluid. Table 1 gives the periods during which the different dilutions were used. The first week, after a change in sperm concentration, was taken as a transitional period, and the results from such a period are not taken into account in the final judgments concerning the effect of semen dilution.

The experimental results of the effect, on fertilization, of sperm concentration are summarized in table 2, for all the hens. It is obvious that the semen may be diluted to a certain extent without affecting its capacity of fertilization. As the 100 percent semen was given to group 2 only, the comparison may conveniently be made for this group. The best fertilization, on the average, was obtained from the 30 percent semen, followed by the 10 percent and 100 percent semen, which show only small differences. The use of 2 percent semen resulted in a decidedly lower percentage of fertilization.

TABLE 2.—*Influence of semen dilution on fertilization*

Data for all hens

Group No. of hens and year of hatching	Results obtained when indicated percentage of semen was used: 2		10		30		100		Results obtained during transitional periods		Total results	
	Eggs laid	Fertile eggs	Eggs laid	Fertile eggs	Eggs laid	Fertile eggs	Eggs laid	Fertile eggs	Eggs laid	Fertile eggs	Eggs laid	Fertile eggs
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
1, hatched 1935, 1936	202	47.5	946	60.1	490	56.3	....	....	297	57.6	1,935	57.5
1, hatched 1937	572	45.3	2,847	70.0	932	66.3	....	....	823	65.5	5,174	65.9
2, hatched 1937	895	55.2	1,386	69.7	1,609	78.2	1,215	67.8	1,005	69.6	6,110	69.4
Total or average	1,669	50.8	5,179	68.1	3,031	71.0	1,215	67.8	2,125	66.3	13,219	66.3
Data with totally infertile hens excluded												
1, hatched 1935, 1936	162	59.3	791	71.9	413	66.8	....	....	233	73.4	1,599	69.5
1, hatched 1937	417	45.3	2,553	78.0	827	74.7	....	....	682	79.0	4,479	76.1
2, hatched 1937	741	55.2	1,234	78.3	1,530	82.2	1,108	74.4	894	78.3	5,507	77.0
Total or average	1,320	64.2	4,578	77.0	2,770	77.7	1,108	74.4	1,809	77.9	11,585	75.6

As regards the time which elapses between insemination and egg laying (table 3), the best results were obtained when the time was 2 days. The eggs which were laid 1 day after the last insemination were in most cases fertilized from an earlier insemination. This is shown by the fact that of the eggs selected there were 83 which were laid no later than 1 day after the hens were inseminated, and only 2 of these eggs were fertile. This fact has also been pointed out by Burrows and Quinn (1937). As more days elapsed between insemination and egg laying the percentage of fertilization decreased.

A comparison of the figures for groups 1 and 2 shows that group 2 yielded the better results. The greater ages of the hens hatched in 1935 and 1936 probably account for the lower percentages of fertilization of these hens, but the age differences between the hens hatched in 1937 in group 1 and in group 2 seem to be too small to be of any importance. One explanation for the difference in results may be that among the hens of group 1 hatched in 1937 there was a greater number of birds with low possibilities of becoming fertilized. That there actually are great individual variations among hens with respect to their possibilities of becoming fertilized can be shown in different ways. Table 2 shows the results obtained when those hens which produced no fertile eggs are excluded. The distribution of the hens according to their class of fertilization is shown in table 4. All hens were not treated with all the different dilutions, and a certain hen which had laid eggs

TABLE 3.—*Distribution of percentages of fertilization according to the number of days elapsing from day of insemination to day of laying*

Item	Distribution according to indicated number of days from insemination to egg laying								
	1	2	3	4	5	6	7	More than 7	Total
Number of eggs laid	5,096	4,225	2,390	769	341	208	86	104	13,219
Percentage of fertile eggs	65.4	71.3	67.3	61.8	49.2	53.8	26.7	25.9	66.3

TABLE 4.—*Distribution of hens of different classes of fertility*

Class of fertility of hens	Percentage of hens in different classes of fertility— When inseminated with indicated percentage of semen in dilution				During whole experiment
	100	30	10	2	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
0-19.9	11.2	15.2	15.0	33.4	11.7
20-39.9	10.0	5.8	7.7	8.1	9.8
40-59.9	13.8	11.1	7.7	16.6	11.3
60-79.9	18.8	17.4	19.6	12.1	23.1
80-99.9	31.2	32.7	35.5	16.6	39.8
100	15.0	17.8	14.5	13.2	4.3
Total number of hens	80	190	220	174	257

when the group to which she belonged was inseminated with 10 percent semen did not necessarily lay any eggs when this group was given 30 percent semen. Table 4 shows, for instance, that 190 hens laid eggs during the time when they were inseminated with 30 percent semen. Of these hens, 17.8 percent laid during this time only fertile eggs, whereas 32.7 percent of the same hens during this same time laid eggs, the percentage of fertilization of which varied from hen to hen between 80.0 and 99.9. Table 4 shows the distribution of individual fertility when the whole experimental time, regardless of different periods and different dilutions, is considered.

In order to make a simultaneous test of the differences between hens and the differences between dilutions, those hens were selected, which had been inseminated with all the different dilutions and during the period of insemination with each dilution had laid at least 15 eggs. Table 5 shows the results from the 14 available hens of this sort. In this table, from each hen 60 eggs—15 from each dilution—are taken into account. When a hen had laid more than 15 eggs during the use of a certain dilution, the last 15 eggs were selected. From the analysis of variance (table 6) it may be seen that both differences, namely, those between dilutions and those between hens, are significant. The same statement applies for interaction, which shows that different hens may

TABLE 5.—*Number of fertile eggs from 14 hens which were inseminated with the different serum dilutions and which, during the use of each dilution, had laid 15 eggs*

Hen No.	Fertile eggs laid by hens inseminated with indicated percentage of semen in dilution			
	2	10	30	100
	Number	*Number*	*Number*	*Number*
H 405	0	0	0	7
H 523	5	9	7	9
H 545	7	14	14	15
H 569	0	1	9	5
H 622	1	0	7	5
H 630	7	5	12	12
H 697	14	15	14	14
H 700	12	14	15	10
H 815	9	3	13	13
H 897	9	11	14	8
H 901	6	8	15	14
H 920	0	0	11	14
H 943	15	15	15	15
H 944	11	14	14	11

TABLE 6.—*Analysis of variance of numbers of fertile eggs produced by hens treated with different dilutions of semen*

Source of variation	Degrees of freedom	Mean square	Test of significance, F
Between dilutions	3	4.7282	8.40
Between hens	13	4.7166	8.37
Interaction	39	0.5632	4.36
Error	784	0.1293	....
Total	839		

react differently to changes in sperm concentrations. As a sudden change may occur in the possibility for a hen to become fertile, this circumstance may influence the part of the variance due to interaction, but the different reactions of, for instance, the four last hens in table 5 seem necessarily to have a real biologic significance.

When our results are compared with those of Burrows and Quinn (1938) for undiluted semen only, it is found that they obtained higher percentages of fertilization. It seems to us that only a minor part of the causes are due to inexperience (viz, from the first weeks of the experiment), whereas the principal cause must be that we have used hens among which there was a greater number which were not possible to fertilize. Many of our birds gave a good percentage of fertilization. For instance (table 4) 46.2 percent, or 37 hens, of those inseminated with undiluted semen gave a fertilization of more than 80 percent. For the hens inseminated with 30 percent, 10 percent, and 2 percent semen the corresponding figures were, respectively, 50.5 percent, or 96 birds; 50 percent, or 110 birds; and 29.8 percent, or 52 birds with more than 80 percent of fertile eggs. During the same time a special experiment was performed by Bonnier and Trulsson (1939) in which, of 210 eggs from 5 hens, 207 were fertile. In this later case all hens were purebred Rhode Island Reds, whereas the hens reported in the present paper were all crossbred. There may be some probability that the crossbred birds are not so easy to fertilize as the purebreds.

Burrows and Quinn (1938) obtained a lower percentage of fertile eggs when the quantity of semen per hen was less than 0.05 cc. From this point of view our results are better than theirs as, 0.05 cc, which was our dosage, of 30 percent, 10 percent, and 2 percent semen corresponds, respectively, to 0.015 cc, 0.005 cc, and 0.001 cc of undiluted semen. The explanation of the difference in our results and in theirs may, therefore, be that most of their hens were of the same type as our hen H 920 (table 5), which had a good fertilization with undiluted semen, not so good with 30 percent semen, but only infertile eggs with 10 percent and 2 percent semen; whereas among our hens are also those with good fertility when all kinds of dilution were used (H 697, H 943) and with low fertility when all kinds of dilution were used (H 622, H 405).

SUMMARY

In the investigation reported, 257 crossbred hens were artificially inseminated with mixed semen from 30 White Leghorn cocks. The semen was given diluted in Ringer solution in the following sperm concentrations: 100 percent, 30 percent, 10 percent and 2 percent. The results show that 30 percent semen, on an average, gives better results than undiluted semen, and 10 percent semen as good results as undiluted semen. In the case of 2 percent semen the percentage of fertilization is decidedly lower.

The greatest number of fertile eggs are obtained when 2 days elapse between day of insemination and day of egg laying. When a longer time elapses the percentage of fertile eggs declines. Eggs which are laid 1 day after insemination are as a rule not fertile from this insemination.

There is a great variation among individual hens in the ability to become fertile. An analysis of variance shows that there are significant differences between hens as well as between dilutions. There is also a significant interaction between hens and dilutions, showing that different hens react differently to changes in sperm concentrations.

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ARTIFICIAL INSEMINATION OF BIRDS

By Prof. Telesforo Bonadonna, *Director of the Institute for Artificial Fertilization of Domestic Animals, Fellow at the Experimental Zooprophylactic Station of Milan, Milan, Italy*

In Italy, the Institute of Milan was the first and until now was the only one which occupied itself with experimental and practical artificial fecundation of birds. Our assistant, Dr. Gaetano Griffini, has specialized in these studies and his first experimental results are interesting.[1]

The practical technique, especially with regard to obtaining the sperm of the male, can be performed in various ways more or less advantageously from three points of view: Practicability, inoffensiveness, and efficiency. Nearly all the methods known at present have been used in this Institute. International literature on this subject is rather scarce.

METHOD OF OBTAINING THE SPERM

This performance is a fundamental and delicate one, which must be executed with experience, ability, and a perfect knowledge of the technique.

The methods are the following: (1) The Russian method of the sperm catcher (applied to the cloaca

[1] Griffini, Gaetano. La fecondazione strumentale nei volatili—fecondazione artificiale degli animali domestici. 7-8-9, XVI. 1938.

of the male) (spermacaptore cloacale), this method having been originated by Timjakov; (2) the Japanese method of the sperm catcher (applied to the cloaca of the female), the method having been originated by Ishikava; (3) the method of electro-ejaculation, chiefly applied in France by Letard, in Russia by Serebrowski, and in Germany by several scientists; and (4) the American method of abdominal massage, first described by Burrows and Quinn.

The electric method is based on the possibility of stimulating the fibers of the nervous system, on which ejaculation depends, by means of opening and closing an electric current of low tension. Although this method has given the very best results in sheep, it has not yet done so in birds, neither with continuous nor with alternating current, and this chiefly because the birds easily experience a shock of their cardiac or respiratory system.

The other three methods have given chiefly the results shown in table 1.

TABLE 1.—*Results obtained from indicated methods of artificial insemination*

Method	Average quantity of sperm obtained per single service	Aspect and color	Average mobility of spermatozoa	Observations
	Cc		*Percent*	
Russian	0.25	Milky	20-40	Mostly contaminated with feces.
Japanese	.30	Dense, milky	100	Pure.
American	.40	Dense, milky	80-100	Sometimes contaminated with feces.

By the method of Ishikava, the pure sperm can be obtained in gallinaceous birds in a very favorable condition for conservation. It has the disadvantage that the cock must become accustomed to copulating with the hen in the presence of man.

The American method of pressing the semen from the bulbous ducts is the simplest and most practical of all. It has been used in our Institute with success in cocks of different breeds, in male turkeys, drakes, male pheasants, peacocks, finches, and canaries.

Burrows and Quinn experimented with 22 cocks kept in cages, from November 8, 1935, to June 1, 1936, and obtained, on an average, with 124 ejaculations from each cock, 2,372 cc of sperm, with a maximum of 203.8 cc from one cock and a minimum of 44 cc from another. The American authors affirm that they have obtained from their cocks from 0.1 to 4 cc respectively in a single service. The operation can be repeated several times a day in most birds without harm.

Our observations agree with those of Burrows and Quinn in that not all the males react in the same way to the abdominal stimulus by massage. The following classes have been found: (1) Males which do not react in any way to the application of the method (1 to 3 percent); (2) those which, from the beginning, react to the application of the method (25 to 30 percent); and (3) those which react to the application of the method only after 2 to 5 applications (60 to 70 percent).

For instance, on November 5, 1938, on the poultry farm of MM. Faravelli, S. Maria la Versa (Pavia), Griffini executed for the first time, on 52 White Leghorn cockerels 7 to 9 months old, the abdominal massage with the following results: 20, or about 38.5 percent, gave sperm with a vitality ranging from 80 to 100 percent, in quantities varying from 0.10 to 0.80 cc in a single service; 20, or about 38.5 percent, reacted rather well to the massage, the liquid ejaculated, however, being free from spermatozoa or containing only a few, these being dead or showing only oscillating movements; and 12, or 23 percent, were completely unresponsive to the massage.

On November 9 and 18 of the same year, 22 cocks on the poultry farm of Dr. Pietro Camussone of Giovenzano (Pavia) were treated in the same manner with the following results: In the first treatment, 8 of 22, or 36 percent, reacted positively to the massage; in the second treatment, 11, or 50 percent, reacted positively.

It was observed that the cocks which were most refractory to the method belonged to the heavy breeds, such as Plymouth Rocks, Rhode Island Reds, and Orpingtons, which are considered by poultry breeders to have a lower reproductive capacity than the lighter breeds. On the other hand, the Wyandottes and the Leghorns responded very well, yielding abundant semen with many living spermatozoa.

On the whole, our experiments allow the following conclusions:

1.—Keeping cocks in the open air, on a well-balanced ration, rich in minerals (especially phosphorus) and vitamins, is of the greatest advantage, quantitatively and qualitatively, for the production of sperm. (The cocks of the Institute are nearly always kept in cages.)

2.—The cocks begin to produce semen at an average age of 4 to 5 months, after which the spermatozoa is continuously increasing in quantity and quality.

3.—Not all the cocks give an equally good production of sperm, nor do the males of all breeds. According to the observations made in our Institute, the White Leghorns are in this respect the best producers, followed by the Wyandottes. This result confirms the practical observations of poultry breeders on the individual and racial variations in fertility of males.

4.—Probably the season of the year, the climatic conditions, the hour of the day, and certainly the state of molt, as well as the manner in which the male bird has been reared, have much influence on the quantity and quality of sperm obtained.

5.—The application of the various methods of obtaining semen—excluding the electric one—has proved innocuous to all the males (gallinaceous, palmipeds, etc.).

Contrary to the Japanese method, the American one has the disadvantage that the sperm obtained is sometimes contaminated with feces. This occurrence, however, is frequently due to a lack of practice on the part of the operator. In the case of such contamination, it is possible to obtain immediately afterwards a new quantity of semen, and this is generally not contaminated. However, if artificial insemination of the female is performed immediately after the obtaining of the sperm, it may be assumed that her genital apparatus will possess a certain degree of natural tolerance to inquination with feces, considering its anatomical structure and the way in which natural fertilization is brought about.

CONSERVATION AND DILUTION OF SPERM

Our experiments on the conservation and dilution of sperm are still rather few. Griffini succeeded in conserving the sperm of a cock under vaseline oil at a temperature of about 5° C. for 120 hours; at the end of this time, more than 40 to 60 percent of the spermatozoa were still rather active. Diluted semen showed less active spermatozoa after conservation for more than 72 hours, and considerable diminution of activity after conservation for 48 hours. In the experiments of Griffini, best results have been obtained by dilution in fresh egg white, as indicated by Nikitina, whereas the Russian medium (abbreviated G.P.F. 44), consisting of glucose and of the phosphates of Ca, Na, and Mg and of egg white, has given rather inferior results, which confirm earlier results of Gretschka.

INSEMINATION OF FEMALES

Letard, Gretschka, Griffini, and others agree on the necessity of introducing the sperm directly into the oviduct and not into the cloaca. The technique is simple and quick, as an extroflexure of the oviduct can easily be produced, by pressing with the fingers, especially in laying hens.

It is sufficient to introduce an average of 0.1 cc of pure and diluted sperm into a hen. Artificial insemination of hens should be repeated once or twice every week, that is, every 3 to 5 days, to obtain a high percentage of fertile eggs. By doing this, Griffini, Bonnier and Trulsson, Burrows and Quinn, and others have been able to obtain, by means of artificial insemination, 100 percent of fertile eggs and a hatch between 80 and nearly 100 percent of the incubated eggs, the Canadian S. S. Munro a hatch of 85-90 percent.

Burrows and Quinn affirm in a publication on their experiments with artificial insemination, in March 1938, that the percentage of fertilization obtained is equal to that with natural insemination. The optimum dose of sperm recommended is 0.05 cc once a week. Smaller doses—as low as 0.02 cc—reduce fertility to barely 34 percent. In cases of low individual fertility, a dose of 0.1 cc of sperm might be used once a week.

Gert Bonnier and S. Trulsson have observed that, although from some hens fertile eggs can never be obtained, in others the fertility is constantly 100 percent. They noted besides that the fertility of sperm is reduced according to the age of the semen used and to the length of the period between the injection of sperm and the deposition of the egg. Hence, 4 days after insemination, the fertility of eggs begins to diminish and it seems that the sperm, as soon as 3 to 4 hours after ejaculation, has a diminished fertilizing ability.

Until now our Institute has made only a few experiments on this subject. Nevertheless we have obtained fertile eggs from hens artificially inseminated 10 days before and with a normal hatch. We have also obtained equally good hatches from fertile eggs, kept for more than 10 days before incubating.

Burrows and Quinn state that as cocks furnish an average of 1 cc of semen daily, a single cock may be sufficient to inseminate about 350 hens once a week, as a result of which, during 1 year, more than 15,000 chickens can be obtained.

It seems to us that artificial insemination has no harmful influence whatsoever on the health of birds.

CONCLUSIONS

Artificial insemination in birds, as in mammals, can be used for scientific as well as for practical purposes.

Among the first advantages that we wish to point out is the possibility of amplifying our knowledge of the sexual, reproductive, and spermatic biology of domestic and wild birds and to effect, in certain cases, the breeding of some wild species which normally cannot be bred in captivity, as well as the production of rare hybrids or of such which otherwise would be impossible to obtain.

From the practical point of view, artificial insemination in the breeding of birds may have the following advantages:

1.—When breeding for selection, especially with rare and valuable males which come from abroad and are high in price, the reproductive capacity of the males can be extended to a much greater number of females than in normal fertilization. In addition, there is the possibility of the exchange and sale of semen, sending it eventually even at a distance.

2.—It will be possible to obtain fertile eggs, even if the hens are kept in cages, as in the case of the so-called battery management, or if, for some unfavorable transitory or permanent reason (narrow cages, small space, unfavorable season) the males do not naturally copulate or do so only occasionally.

3.—It will be possible for the poultry breeder as well as for the general aviculturist to obtain, by artificial insemination, certain crosses and special hybrids asked for by fanciers, for artistic and ornamental reasons, which are difficult or impossible to obtain in natural fecundation. This means also new possibilities for marketing singing or ornamental birds or those bred for their feathers.

Artificial insemination in birds is practical, simple, and easily learned. However, the obtaining of semen as well as the use of it must always be done with the strictest observation of the method of procedure, with precaution and understanding of the vital necessities in the handling of the semen.

SUMMARY

Artificial insemination of birds is advantageous for three reasons: (1) It facilitates scientific studies on production of spermatozoa and on the development of hybrids; (2) it results in fertile eggs being obtained from females which otherwise cannot be easily mated with males (in so-called battery management); (3) it increases the reproductive possibilities of one male by mating him to a greater number of females, which is of the highest advantage for selection.

The researches of the Institute for the Artificial Insemination of Animals at Milan, Italy have given the following results:

It is possible, but rather complicated, to obtain spermatozoa by means of sperm catchers in fowls and waterfowls; however, the sperms obtained in this way are purer and more conservable.

The so-called American method, consisting in an abdominal massage and in pressing the bulbous ducts, is simple, practical, and possible to perform in nearly all birds (cock, male turkey, drake, male pigeon, finch, pheasant, etc.).

In general, the sperm of birds is rather easily kept viable, but the characteristic qualities of the production of spermatozoa and the intensity of lust seem to depend, especially in some species of birds, on the season of the year, the kind of management, nutrition, etc.

Solutions for the dilution of the sperm of birds known until now, seem not yet sufficiently adapted to the purpose.

The artificial insemination of females is generally easy, and the introduction of very small quantities of sperm directly into the oviduct results in general in a fertility of 90 to 100 percent in the eggs, though there are rather considerable individual variations.

No harm to the birds subjected to artificial insemination could be observed and, the progeny obtained do not appear to differ in development, prematureness, vitality, lust, etc., from those naturally sired.

ARTIFICIAL INSEMINATION OF CHICKENS AND TURKEYS[1]

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INTRODUCTION

Artificial insemination offers poultrymen a practical means of a more economical use of valuable sires, a possibility of carrying on a mating that might otherwise have to be discontinued because of accidental crippling of the sire, and a solution to the problem of fertilizing the eggs of hens in batteries. Also, by transportation of semen, hens in several localities may be inseminated with semen from a single sire without moving the sire about and thus exposing him to possible infectious diseases. Artificial insemination has long been considered a valuable tool for research in fertility studies, in the work of crossbreeding in which natural matings are difficult or impossible, and in numerous other studies in which reproduction is involved.

As early as 1913, Ivanov (*14*)[2] inseminated hens with semen taken from freshly killed cocks. Amantea (*2*), in a study of fowl spermatozoa, and Dunn (*11*), studying selective fertilization, collected semen on a dish placed between the cock and hen during copulation. Craft, McElroy, and Penquite (*10*) studied the effect of feeds on spermatozoa, which they collected from the cloaca of the hen with a glass spoon after copulation. Payne (*18*) used a glass spoon to obtain semen for artificial inseminations. Jull and Quinn (*15*) recovered semen from the hen's cloaca with a pipette in their work of crossing bantams with large fowl. Ishikawa (*13*) devised an artificial cloaca from membrane and wire which he fastened to the hen to catch semen for his study of the viability of spermatozoa outside the body. Adamstone and Card (*1*) modified the artificial cloaca, using thin rubber in place of the membrane, for their study of fowl spermatozoa.

The writers and their coworkers have been investigating the problems of artificial insemination of chickens and turkeys at the Agricultural Research Center, Beltsville, Md. since late in 1934. The work has followed naturally through two phases and into the third. First a practical method for the collection of semen was developed. Later a rapid and efficient means of inseminating females was devised, and recently a study of the problem of sperm storage was begun.

[1] Burrows, William H., and Quinn, Joseph P. U. S. Dept. Agr. Circ. 525, illus. (In press).

[2] Italicized numerals in parentheses refer to Literature Cited, p. 84.

COLLECTION OF SEMEN AND INSEMINATION OF FEMALES

Several approaches to the problem of collecting semen were investigated. An attempt to massage the vas deferens through the cloaca was unsuccessful, as were attempts to improve methods previously in use. An attempt to adapt the electrical stimulation used with the guinea pig by Battelli (*3*) was disappointing; no semen was obtained and fatalities were numerous.

The writers, while working with intra-abdominal injections pertaining to another experiment, observed that one bantam male ejaculated when its abdomen was pinched up preparatory to injection. From this observation was developed a method of obtaining semen by massage of the abdomen which Burrows and Quinn (*6*) reported in 1935. The method was later improved in that semen was milked directly from the bulbous ducts of the copulatory organ, as described by Burrows and Quinn (*7*), thereby making the process independent of the ejaculatory response.

The method in its present form enables two operators to handle about two birds a minute and to obtain all their available semen. Burrows and Titus (*9*) obtained an average of 1 cc of semen for each daily collection in more than 3,000 collections from 22 males of a three-way cross: White Leghorn male × F_1 female (Rhode Island Red male × Barred Plymouth Rock female). However, males of other breeds, such as Rhode Island Red, have been found to produce an average of only 0.5 cc per daily collection. Burrows and Quinn (*8*) show that individual cocks yield from 0 to 4.0 cc of semen at a collection. In most breeds the average yield is probably less than 1 cc per collection. Burrows and Marsden (*5*), reporting on work with Bronze, White Holland, Standard Black, and Bronze × White Holland crossbred turkeys, show that semen production in these birds varies from 0.1 to 0.7 cc for each collection with an average of 0.3 to 0.4 cc.

The work of Burrows and Titus (*9*) demonstrates that semen production is closely correlated with testis size, but that such external characteristics as size and color of wattles and comb and a willingness to mate are not reliable indices of semen production.

A technique for inseminating hens was developed by Quinn and Burrows (*19*), which consists in exposing the orifice of the oviduct and injecting semen into it. With this technique, two experienced operators can inseminate about 200 hens an hour. The fertility obtained varies from mating to mating and with the individual hen, as it does in natural matings. Weekly inseminations of 0.1 cc, and in some instances 0.05 cc, have yielded fertility of 97 percent in some matings, whereas other matings have given only 89 percent fertility of eggs after the most careful inseminations. Carelessness of technique, such as the use of samples of semen containing urine, or the failure to introduce the semen into the oviduct, results in very poor fertility. Burrows and Marsden (*5*) were able to maintain a fertility of 80 percent in turkey hens for 4 weeks after three successive daily inseminations of 0.05 cc of semen. All inseminations referred to were made with mixed semen from a number of males. Warren and Scott (*21*) attempted a turkey-chicken cross, as did Quinn, Burrows and Byerly (*20*). In both cases fertile eggs and embryos were obtained, but no living hybrids hatched.

STORAGE

Most of the early work at Beltsville was concerned with the development of routine methods for use in experimental procedures and in the practical application of the technique for the fertilizing of eggs from hens in batteries. In this work the major consideration was maximum fertility, and for it semen was used as soon as possible after collection. However, it is not always convenient to use semen immediately after it is collected. In any work that involves the transportation of semen the problem of storage arises.

Grodzinksi and Marchlewski (*12*) made an extensive study of motility of spermatozoa outside the body, as have several besides those already mentioned. Observations at the Agricultural Research Center showed that undiluted semen would retain motility for as long as 10 days at temperatures of 2° to 4° C. It was also observed that some spermatozoa apparently lost their ability to fertilize eggs while they still retained a high degree of motility. Mammalian spermatozoa have been stored at temperatures slightly above freezing and still retained their fertilizing ability. However, Birillo and Puhalzskii (*4*) have reported that rapid chilling of mammalian spermatozoa resulted in the loss of their ability to fertilize. Munro (*16*) found that fowl spermatozoa are immobilized at temperatures of about 105° F. if surrounded by the proper media, that is, certain saline solutions and the fluids of the magnum and infundibulum of the oviduct. Such spermatozoa, he says, again become motile when subjected to media other than that which immobilize them. In view of these findings, the study to observe the effects of storage, under various conditions, on the fertilizing ability of cock spermatozoa was recently begun. This study has not yet resulted in a satisfactory method for storing semen, but the results obtained thus far indicate rather definitely what some of the limitations of the work will be. Table 1 gives the conditions and results of these preliminary observations.

In the present study semen was used from composite samples of 10 or more cocks in all instances. Samples were collected, a portion tested for its fertilizing ability while fresh, and the rest of the sample saved for subsequent tests after being subjected to various conditions of storage. All tests were made by a single insemination of a number of hens with 0.1 cc of semen, and collecting and incubating their eggs from the second to the ninth days. The eggs were then broken and observed for fertility.

Different samples were stored at 1.6°, 2°, 4.4°, and 20° C. One of the samples stored at 4.4° C. was cooled very slowly. The sample stored at 1.6° C. was tested after 2 days of storage. A sample held at 2° C. was tested after 2, 4, and 6 days of storage, and one held at 4.4° C. was tested after 2, 4, 8, and 25 hours. The sample held at 20° C. was tested after 2, 4, and 8 hours.

One sample was diluted with Ringer-Locke solution and subjected to 105° F. (40.5° C.), but

TABLE 1.—*Results of inseminations*[1] *with sperm freshly collected and stored under different conditions*

Sample No.[2]	Treatment of sperm	Hens	Eggs		
			Fertile	Infertile	Total
		Number	*Number*	*Number*	*Number*
1	Freshly collected	10	25	7	32
2	Stored for 2 days at 1.6° C.	10	0	33	33
3	Stored for 2 days at 2° C.	10	0	46	46
4	Stored for 4 days at 2° C.	10	0	45	45
5	Stored for 6 days at 2° C.	10	0	44	44
6	Stored for 2 days at 4.4° C.	10	0	23	23
7	Freshly collected	6	18	3	21
	Stored at 4.4° C. for—				
	2 hours	6	0	21	21
	4 hours	6	0	25	25
	8 hours	6	0	21	21
	25 hours	6	0	17	17
8	Freshly collected	10	30	16	46
	Stored at 20° C. for—				
	2 hours	10	15	10	25
	4 hours	10	0	21	21
	8 hours	10	4	38	42

[1] All semen was from composite samples and showed good motility at the times of insemination. Eggs were collected from the second to ninth days after insemination with 0.1 cc of semen in every case.

[2] Sample 6 was cooled slowly; others were chilled rapidly.

this sample lost its motility and became putrid at such a rapid rate that no tests were made with it.

As shown in the table, no fertility was obtained with any of the semen from the samples that were subjected to temperatures of 4.4° C. or lower. The sample that was cooled slowly gave results no different from those that were cooled rapidly. These results are rather surprising in view of the work with mammalian sperm and the excellent motility retained by fowl sperm under these temperatures. The results obtained at high temperature suggested at once that any further work in that direction would necessarily involve some means of controlling putrefaction. At 20° C. the fertilizing ability of spermatozoa was not lost so rapidly as at other temperatures tested and at the end of 8 hours these spermatozoa were still able to fertilize a small percentage of the eggs. The data on this point, however, are too few to permit more than the conclusion that at 20° C. some fertilizing ability is retained for 8 hours. Further work is necessary at temperatures near 20° C.

SUMMARY

The writers have developed a method at the Agricultural Research Center, Beltsville, Md., by which two operators can obtain the available semen from about two cocks a minute. The semen is milked directly from the bulbous ducts of the copulatory organ. Insemination of hens as described by Quinn and Burrows can be made at the rate of about 200 birds an hour by direct injection of semen into the exposed orifice of the oviduct.

The semen production of cocks averages about 0.5 to 1 cc per daily collection. Semen production in turkey toms averages 0.3 to 0.4 cc per daily collection. On the basis of mixed samples from several males, 0.1 cc of cock semen introduced into hens at weekly inseminations results in excellent fertility, and 0.05 cc of turkey semen given in daily inseminations for 3 days results in good fertility for a period of 4 weeks.

In recent experiments, when semen was stored at temperatures of 4.4° C. and lower, the spermatozoa were found to have lost their ability to fertilize eggs in the short time of 2 hours. When semen was stored at body temperature of the hen (40.5° C.), it became putrid at a rapid rate. Spermatozoa stored at 20° C. retained some of their ability to fertilize eggs for 8 hours, but the number of fertile eggs obtained decreased as the time of storage increased.

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ALLOMETRIC STUDIES OF POULTRY

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The study of relative growth, heterogony, or allometry, as it is variously termed, forms an important field in biological research. Ramifications arising from the simple expression relating the size of a part to the size of the whole or of another part have received wide attention from investigators working with plants, with invertebrate organisms, with laboratory animals, with paleozoological organisms, not to mention the interest that biomathematicians have displayed in this connection. In the course of the present discussion references will be made to a number of these investigations, most of which have been ably summarized by Huxley (1932), Needham (1934), Sinnott and Dunn (1935), Teissier (1936), and others.

Workers with poultry seem to have neglected the possibility of applying the concepts arising from the studies on allometry. It is the purpose of this paper to point out some of the neglected possibilities and to discuss a number of applications of these concepts to problems of research in the field of poultry production.

THE ALLOMETRIC EQUATION

The basic allometric relationship is that expressed by the equation

$$y = bx^{\alpha} \qquad (1)$$

in which y represents a part, x another part or the whole, b the initial growth index or the value of y when x equals unity, and α the growth ratio or the actual or limiting equilibrium constant, according to Huxley and Teissier (1936).

The derivation of this relationship can be made in several ways, as stated by Lumer (1937). Suffice it to say that α may be considered to represent the ratio of the relative growth rate of y to the relative growth rate of x. In logarithmic form equation (1) becomes

$$\log y = \alpha \log x + \log b \qquad (2)$$

and if α is constant throughout a given range of change in y and in x, a straight line is obtained on a log-log plot, with log b as intercept and α as the slope. Of the several ways of determining the allometric constants α and b, probably the most accurate ones are the least-squares solutions, given by Schmalhausen (1931) and by Feldstein and Hersh (1935a).

It is evident that α and b provide simple numerical bases of comparison of growth patterns of parts, organs, dimensions, and chemical constituents of an organism. There are, however, certain complicating factors involved in this relationship that lead to limitations in the use of the allometric equation and that it may not be amiss to discuss at some length.

LIMITATIONS OF THE ALLOMETRIC EQUATION

Thus, it must be realized, as stated by Brody, Davis, and Ragsdale (1937) that α should not be considered as a true entity, although attempts have been made to interpret it in physico-chemical terms. As Needham (1934) has pointed out, α is a pure dimensionless number, since if it is different from unity the dimensions on the two sides of the equation are not equivalent and do not answer the equivalence requirement of the theory of dimensions. Mathematical criticisms of the equation have been made by Bernstein (1934), by Richards (1935), and by Lumer (1937). Bernstein states that the idea of a constant partitioning of materials, such as visualized by Robb (1929), is not tenable. The conclusions of Richards are unfavorable to the thesis that the equation represents a fundamental law. Similarly, Lumer does not consider it adequate for investigations involving fundamental principles of relative growth, though concluding that it is a useful approximation to some more precise law.

We may consider equation (2) as a special case of the general logarithmic regression formula. Involving different variables, such regressions have been used by Schmalhausen (1931) and in a special application to posthatching growth by Lerner and Asmundson (1938) and by Lerner (1938b). The present discussion, however, confines itself to part-part and part-whole relationships only. It may be said with Huxley (1932) in connection with the statements referring to the mathematical criticisms, that even if we are dealing with approximations, "to have a quantitative expression in place of a vague idea of a general tendency is not merely a mild convenience." The quantitative expression herein involved, aside from all idea of partition, is the ratio of the relative developmental rates

$$\frac{dy}{ydt}\Big/\frac{dx}{xdt} = \alpha \tag{3}$$

and as such has its definite utility.

The caution of Gray (1929) and Richards (1935), the latter specifically regarding the allometric equation, against graphic fits of logarithmic equations should be kept in mind. Fortunately α and log b values can be tested for validity by the use of the standard errors as given by Schmalhausen (1931), Feldstein and Hersh (1935b), and Lerner (1936).

It may be seen from equation (3) that the time dimension is removed from α. This may constitute an objection in the case of the actual growth constants, that is to say, constants expressing actual rates (as contrasted with the limiting values of α, or limiting equilibrium constants). Glaser (1938) discusses the question of bringing the time dimension back into the allometric equation. An interesting attempt at tridimensional representation, though on a nonlogarithmic scale, has been made by Clark (1936).

Another point to be remembered is that α for individuals may differ from the α values calculated on the basis of averages, as shown by Hersh (1938). Finally, the constancy of α should be definitely ascertained before its calculation is undertaken for the whole range of observation. As has been shown by Lerner (1938a), apparently straight-line plots for a large range may in reality include tangential fluctuations. A further illustration of this point may be made from the data of Lerner and Gunns (1938).[1] In White Leghorn embryos at ages between 9 and 20 days, the weight of the eyeball gives an α value, with respect to the weight of the embryo, of 0.260 for males and 0.264 for females. In reality a constantly decreasing growth ratio obtains. If the whole period is broken down into 4-day stages, the respective α values are as follows:

Age (days)	Males	Females
9–12	0.429	0.470
13–16	.252	.209
17–20	.201	.190

Nevertheless, the values for the whole period have a meaning of their own in many such cases (where their reality is ascertained by the computation of the standard errors), giving an average ratio for the particular period.

With such limitations as these in mind, a number of problems on which the allometric equation may be profitably employed may be mentioned.

BODY PROPORTIONS

Thus with respect to the growth patterns of the breast muscle and the length of the leg bones of the fowl, Lerner (1937) has shown that Barred Plymouth Rocks and Black Minorcas are identical. Furthermore, indications were obtained that other breeds showed similar limiting equilibrium growth ratios for the shanks. The Bantams, however, were found to be an exception to this, having lower values than the larger breeds. Additional limited data obtained[2] tend to support this conclusion for both the breast muscle and the shank.

The fact that the weight of the breast muscle in relation to body weight exhibits positive allometry (α being larger than unity) leads to changing proportions with age. Thus in a mixed population of 590 Barred Plymouth Rocks and crosses between Barred Plymouth Rocks and White Leghorns, it was found that the percentage of body weight formed by one side of the large breast muscle varied with age according to the following:

Age (weeks)	Males	Females
	Percent	*Percent*
4	2.09	2.25
8	2.80	3.53
12	3.48	3.69
16	3.48	3.97
20	3.83	4.08

Through the use of the allometric equation such age effect can be expressed by a single value. The least-squares determination of α yields the values of 1.240 for males and 1.245 for females. These figures, incidentally, show a close agreement with values previously reported for Barred Plymouth Rocks and for Black Minorcas by Lerner (1937).

In relation to the study of proportions, a state-

[1] Unpublished data.

[2] Unpublished data.

ment by Robb (1932) may be profitably introduced into this discussion:

Hitherto there has been lacking an adequate technique for the recognition, and description, of quantitative characters. The ratio, favorite of anthropologists, is even more fallacious than the bimodal curve. Each presumes to define the phenomenon (which involves an entire sequence of point-events from fertilization to decay) by one cross section made at an arbitrary point in time. Even though the unit-character be viewed as a four-dimensional object in space and time, its properties are not immediate functions of the time dimension; hence that convention is also misleading.[3]

It seems clear from this citation that, for instance, genetic studies of shape or conformation which do not take account of developmental rates address themselves to the method of inheritance of something that is the result of interaction of a number of processes rather than to the inherited factors themselves. By means of allometric constants describing growth in different dimensions, we should be able to isolate the inherited factors themselves. Shape is a function of these rates and of time or duration of growth from the beginning of growth of any particular dimension to the time of its approach to the upper asymptote. A cross section or ratio taken at any point in time does not permit us to judge of the genetic differentials involved either in the final shape or in the conformation at any given time, for instance, when birds are to be marketed. For purposes of selection we do not know whether this selection is to be made for developmental rate in one particular direction or for time relationships.

The quantitative nature of the characters involved must be appreciated. Although these characters have been termed quantitative for many years, they are still treated as qualitative differences. Attention should be centered on the processes leading to the assumption of the specific form rather than at the end products themselves. Allometry is one of the methods which permits us to do that, and its utility in this connection should not be neglected.

Jaap (1938) made an approach to the relative growth function by using the ratios of different dimensions to the cube root of body weight, although he thus selected only a special case of limiting allometry rather than a generalized (through the use of logarithms) application of this function. Furthermore, the use of limiting constants instead of the actual growth constants does not reveal the operation of the inherited features of developmental rates controlling shape. To emphasize this point, it may be said with Sinnott (1937) that "just what a gene controls must be learned before we can understand how the gene controls it." If Thompson's (1917) dictum that form is the result of differential growth is accepted, the genes may be expected to control rates and not final proportions. Such single rates and particularly patterns may be readily described in terms of the allometric equation, the inherited growth relationship constants being "the real expression of genic activity or the true" characters themselves. It is sufficient to recall Kopec's (1927) study on inheritance of shape for an illustration of the inadequacy of the alternative approach that utilizes limiting dimensional ratios only. The reader is referred to the review by Sinnott and Dunn (1935) and to Kaiser's (1935) paper for a further discussion of this topic. Huxley (1932) also discusses in detail the determination of growth gradients, for examples of which with poultry the reader is referred to the papers by Lerner (1936, 1937).[4]

The study of limiting α values, however, may also be profitably employed. An example of this may be given from tables VII and X of Maw (1933). Thus if log-log plots are made of the body weights at 26 weeks of age against two of the measurements selected at random, the following may be seen:

1. Circumference of the body behind the wings tends to give a straight line for all breeds and crosses, with the exception of the Cornish. In other words, the limiting α value of this dimension is uniform in these breeds, whereas the distinguishing feature of the Cornish is the larger circumference at the same body weight.
2. Length from wings to beak, on the other hand, does not yield the same kind of plot and may apparently be a breed character irrespective of body weight. This example illustrates how the possibility of selection for desirable body shape is enhanced by the use of the simple analyses suggested.

CHEMICAL ALLOMETRY

Another interesting application of the relative growth function is involved in the concept of chemical allometry, first utilized by Teissier and cited by Needham (1934). Needham, comparing the allometric constants of various chemical constituents of different animals, concludes that a uniform chemical ground plan of animal growth seems to exist. There is, however, a certain range of intraspecific variation, such as is found in the case of glutathione concentration in newborn rabbits by Lerner, Gregory, and Goss (1936). Similar variation though not so clean cut was found by Gregory, Goss, and Asmundson (1937) in chickens.

On the other hand, preliminary work on the rate of fat deposition in the breast and thigh muscles, carried on in this laboratory, has revealed no discernible differences in the early stages of growth between Barred Plymouth Rocks and White Leghorns. Significant intermuscle differences were, however, found. Such differences lead to the differences in fat contents of the

[3] It should be noted here that the time dimension, however, cannot be entirely neglected.

[4] The 1936 paper has been erroneously entitled "Heterogony in the *axial* . . . " rather than *appendicular* "skeleton of the Creeper fowl."

breast and thigh at later ages, found by Maw and Puddington (1937) and by Harshaw (1938). The data of Harshaw for breast fat yield an α value (breast fat to breast weight) of 1.476 $\pm$ 0.263, which, in the light of its standard error, is a valid constant. His data on the thigh fat appear to be too erratic to give a significant value.

STUDIES OF EGGS

The relative growth function may be extended to studies of eggs. Thus Huxley (1932) found an intraspecific relation between egg white and body weight, the α value in Carinatae being 0.67. In this laboratory, a flock of 434 White Leghorns weighing from 1,300 to 2,299 grams yielded an α value of 0.299 $\pm$ 0.010, the data being grouped. Similarly, the data of Graham, cited by Jull (1932, *p.* 220) show α to equal 0.314 for his 1929 flock of Rhode Island Reds. His 1928 flock, owing to the irregular variations in the data, was not amenable to such analysis. There is considerable room for studies of this sort to determine the nature of egg-size fluctuations with breed, age, season etc., which lead to valid allometric relations in some cases and not in others.

The size of egg parts in relation to total egg size is undoubtedly an allometric function. Hendricks, Lee, and Godfrey (1931) have used it in a modified form

$$y = b(x - y)^{2/3} \tag{4}$$

in relating the amount of shell to egg weight. Taylor and Lerner (1939) preferred a simple percentage value, but their choice was governed by a series of considerations, which may be particular to the data involved and not general. As an illustration of the allometric relationship between yolk and egg weight, the data of Curtis (1914) (mean monthly values of bird No. 218, tables 24 and 26) give an α value of 1.496.

The exigencies of space prevent any further discussion of the application of the principles of allometry to problems of poultry production. The examples cited are probably sufficient to bring out the convenience of expressing various quantitative relationships by means of the relative growth equation. The exhaustive monograph of Huxley (1932) presents many further elaborations involving genetics, physiology, embryology, etc. If the present discussion serves to stimulate the use of the principles enunciated by Huxley, Teissier, and other workers to whom reference has been made, in connection with the problems of poultry production, it has amply fulfilled its purpose.

SUMMARY

The concept of allometry, using the simple relationship obtaining between the relative growth rates of a part and of the whole, finds ready application in the studies of problems of poultry production. Easily calculated ratios, expressing growth patterns of parts, organs, or dimensions, can aid in genetic and physiological interpretations of results obtained in many diverse problems. Body conformation, percentage of different kinds of flesh, chemical composition of poultry meat, egg size, weight of parts of the egg, and other factors may be analyzed from the standpoint of relative growth. A general review of literature, with suggested applications and illustrative material with respect to these, is presented, and certain limitations of the methods described are discussed.

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EFFECT OF THREE ENVIRONMENTAL VARIABLES ON GROWTH AND SEXUAL DEVELOPMENT OF CHICKENS

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Growth and sexual development of chickens are two heritable characters of vital interest to commercial poultrymen and poultry scientists. The response of chickens to three environmental variables—brooder-house temperature, brooder-house relative humidity, and the ration fed—is reported.

EXPERIMENTAL

Series C.—Four groups of 125 sexed Barred Plymouth Rock chicks were placed in especially insulated colony brooder houses of the type described by Nicholas and Callenbach.[1] Two of the houses supplied a high and constant temperature accompanied by a low relative humidity. The other two provided a lower temperature, which fluctuated with outside conditions, and a correspondingly higher relative humidity. The chicks placed in one warm and one cold house were fed the regular Penn State chick starter and laying mash. Those placed in the other two houses, providing similar environments, were fed the same mash, with the addition of a grain mixture after the eighth day. In all cases the feed mixtures were constantly available in feeders of appropriate size. Brooding equipment and management were the same in all houses.

Each house group was divided into seven subgroups, one of which remained in its original brooding quarters for the duration of the 9-week brooding period. The other six subgroups were transferred at 1, 2, 3, 4, 6, and 8 weeks of age to the other house providing opposite conditions of temperature and relative humidity but the same ration. Thus, there were 28 subgroups in the series.

Series D.—Four groups of 125 sexed Single-Comb White Leghorn chicks were brooded in the same houses as series C and under similar conditions, but with provisions for supplying moisture in the two warm houses. Subgroupings and transfers were made in the same manner as for series C. The two mash- and grain-fed groups had grain available after the third day.

RESULTS

Figure 1 shows graphically the temperature and relative humidity conditions to which the seven subgroups of group 1, series D, of the Single-Comb White Leghorns were exposed. It illustrates the changes in environment experienced by all subgroups and the basis for calculating average temperatures and relative humidities (tables 1 and 2). These averages, which are described as ascending or descending according to whether the groups were transferred from high to low conditions or vice versa, are for the first 8 weeks of the rearing period. Thereafter, environmental conditions, except for the ration fed, were similar for all large groups and subgroups.

Growth and sexual development as measured by weight and age at sexual maturity (tables 1 and 2)

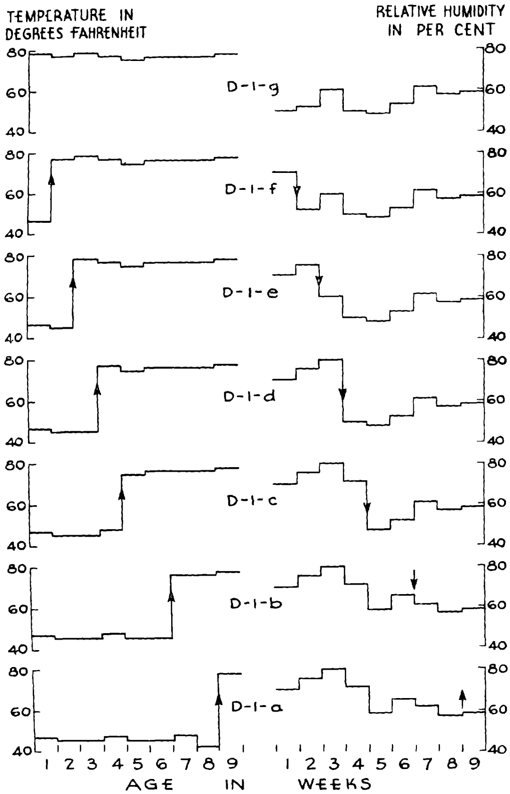

FIGURE 1.—Brooder-house temperature and relative humidity for Single-Comb White Leghorns in the seven subgroups of group 1, series D.

demonstrate no influence of either brooder-house temperature or relative humidity when these factors are constant or fluctuating within the limitations of the experiments described. The subgroups of groups 3 and 4 of both series C and D, which were fed the Penn State chick starter and laying mash only gave results similar to those tabulated for subgroups fed grain and mash (tables 1 and 2).

The effects of feeding a mash containing 18.5

[1] NICHOLAS, J. E., and CALLENBACH, E. W. Air conditioned poultry brooder houses. Agr. Eng. 17, 12:518-521. 1936.

TABLE 1.—*Effect of temperature and relative humidity on weight and age at sexual maturity of comparable subgroups of Barred Plymouth Rocks and Single-Comb White Leghorns*

Groups C-1 and D-1, fed mash and grain ad libitum

Barred Plymouth Rocks					Single-Comb White Leghorns				
Subgroup designation	Average temperature (ascending)	Average relative humidity (descending)	Sexual maturity		Subgroup designation	Average temperature (ascending)	Average relative humidity (descending)	Sexual maturity	
			Average weight	Average age				Average weight	Average age
	°F.	*Percent*	*Grams*	*Days*		°F.	*Percent*	*Grams*	*Days*
C-1-a	47	69	2,204	184	D-1-a	52	67	1,645	167
C-1-b	52	61	2,466	176	D-1-b	58	66	1,797	169
C-1-c	60	51	2,458	185	D-1-c	63	64	1,742	167
C-1-d	64	46	2,214	173	D-1-d	67	62	1,654	164
C-1-e	67	42	2,431	180	D-1-e	70	60	1,779	166
C-1-f	71	37	2,280	179	D-1-f	74	57	1,754	167
C-1-g[1]	74	33	2,435	177	D-1-g[1]	77	55	1,728	166

[1] This subgroup was kept continuously in its original brooding quarters.

TABLE 2.—*Effect of temperature and relative humidity on weight and age at sexual maturity of comparable subgroups of Barred Plymouth Rocks and Single-Comb White Leghorns*

Groups C-2 and D-2, fed mash and grain ad libitum

Barred Plymouth Rocks					Single-Comb White Leghorns				
Subgroup designation	Average temperature (descending)	Average relative humidity (ascending)	Sexual maturity		Subgroup designation	Average temperature (descending)	Average relative humidity (ascending)	Sexual maturity	
			Average weight	Average age				Average weight	Average age
	°F.	*Percent*	*Grams*	*Days*		°F.	*Percent*	*Grams*	*Days*
C-2-a	70	38	2,444	175	D-2-a	75	54	1,729	169
C-2-b	65	46	2,380	177	D-2-b	69	54	1,735	164
C-2-c	58	56	2,241	175	D-2-c	64	57	1,724	164
C-2-d	53	61	2,253	178	D-2-d	60	59	1,725	172
C-2-e	50	66	2,320	176	D-2-e	57	61	1,738	166
C-2-f	47	70	2,247	179	D-2-f	53	64	1,721	174
C-2-g[1]	43	75	2,300	174	D-2-g[1]	50	66	1,699	166

[1] This subgroup was kept continuously in its original brooding quarters.

TABLE 3.—*Effect of ration fed on weight and age at sexual maturity of comparable subgroups of Barred Plymouth Rocks and Single-Comb White Leghorns*

Barred Plymouth Rocks					Single-Comb White Leghorns				
Series and group, and subgroup	Average weight at sexual maturity of birds receiving—		Average age at sexual maturity of birds receiving—		Series and group, and subgroup	Average weight at sexual maturity of birds receiving—		Average age at sexual maturity of birds receiving—	
	Mash	Mash and grain	Mash	Mash and grain		Mash	Mash and grain	Mash	Mash and grain
	Grams	*Grams*	*Days*	*Days*		*Grams*	*Grams*	*Days*	*Days*
C-1 and C-3:					D-1 and D-3:				
a	2,253	2,204	193	184	a	1,745	1,645	168	167
b	2,219	2,466	194	176	b	1,690	1,797	169	169
c	2,342	2,458	194	185	c	1,647	1,742	169	167
d	2,310	2,214	190	173	d	1,503	1,654	168	164
e	2,181	2,431	187	180	e	1,628	1,779	166	166
f	2,303	2,280	183	179	f	1,666	1,754	168	167
g	2,295	2,435	179	177	g	1,664	1,728	169	166
C-2 and C-4:					D-2 and D-4:				
a	2,415	2,444	199	175	a	1,663	1,729	161	169
b	2,273	2,380	183	177	b	1,661	1,735	161	164
c	2,177	2,241	182	175	c	1,687	1,724	169	164
d	2,253	2,253	184	178	d	1,636	1,725	166	172
e	2,246	2,320	204	176	e	1,692	1,738	173	166
f	2,246	2,247	190	179	f	1,769	1,721	178	174
g	2,267	2,300	193	174	g	1,792	1,699	187	166

percent of protein and the same mash plus unlimited quantities of a grain mixture of corn, wheat, oats, and barley, are shown in table 3. The data definitely refute the widespread opinion that heavy grain feeding of immature pullets has a retarding influence on sexual development. In fact, the converse was particularly evident in the Barred Plymouth Rocks. Every grain-fed subgroup of this variety matured at a younger age than its paired subgroup fed mash only. From the standpoint of growth the evidence is almost equally conclusive in both varieties. These results are contrary to expectations based on protein-level and sexual-development relationships determined with all-mash rations. It is possible that the physical constitution of the total feed intake may be a more important factor in poultry nutrition than it has heretofore been considered.

SUMMARY

Eight groups of sexed pullet chicks were reared with similar brooding, feeding, and watering equipment in especially insulated brooder houses. In one series of four groups the house temperature and the ration fed were carefully controlled but the humidity was variable. In the other series of four groups humidity also was controlled.

Each house group was subdivided into seven subgroups, six of which were transferred at various ages from their original quarters to another house supplying contrasting temperature and humidity conditions but the same ration. Thus, in the eight large groups there were 56 subgroups exposed to both similar and dissimilar environments for different lengths of time during a 9-week brooding period. After 9 weeks the environment, except for the ration fed, was the same for all large groups and subgroups.

Within the limits provided in these experiments, neither brooder-house temperature nor brooder-house relative humidity had any measurable influence on growth or age at sexual maturity.

Ad libitum feeding of a grain mixture, in addition to an 18.5-percent protein mash, after 3 or 8 days of age (for series D and C, respectively) did not retard sexual development. In fact, in the 28 pairs of subgroups exposed to the same conditions except for all-mash in one case and mash and grain in the other, 23 of the subgroups fed mash and grain matured earlier than the corresponding subgroups fed all-mash, and 21 subgroups fed mash and grain had greater average weights at first egg than the corresponding subgroups fed all-mash.

EFFECT OF ANDROGENS ON THE CHICK[1]

By W. R. BRENEMAN,[2] *Assistant Professor, Waterman Institute, Indiana University, Bloomington, Indiana, U. S. A.*

The value of the fowl as a test animal for endocrine research has increased greatly in the last few years. Careful study of male-hormone thresholds by Greenwood and others (1935) and the development by Tschopp (1935) and Fussganger (1934) of the method of direct application of androgens to the comb have made the capon-comb test more useful for male-hormone standardization. Earlier work by Riddle and Polhemus (1931) and by many others emphasized that the testis of the dove and pigeon is very responsive to small quantities of pituitary gonadotropic hormone. Domm and Van Dyke (1932), Schockaert (1933), and Breneman (1936) have demonstrated that this latter generalization also applies to the fowl. It is obvious from these facts that the cockerel is especially well adapted for use in a study of pituitary-gonad interrelationship: The comb responds to small quantities of androgens and the testes reflect slight variations in pituitary hormone level. We have endeavored, in our laboratory, to study the various aspects of male-hormone action in the baby cockerel as demonstrated by stimulation of comb growth and the crowing reaction and by inhibition of testicular growth. This study has also been supplemented by an analysis of the normal development.

MATERIAL AND METHODS

Single-Comb White Leghorn cockerels were used as experimental animals. These were all obtained from one hatchery, and controls were checked against each experimental group whenever possible. Control chicks were kept in the same cages with treated birds in a battery brooder in order that conditions such as feed, water, and light would be uniform for all animals. Unpublished data from this laboratory show that crowding chicks or limiting their feed is followed very quickly by lower gonad weights and lessened response to male hormones. These factors, therefore, must be controlled as carefully as possible.

The synthetic male hormones employed were supplied through the courtesy of Dr. Max Gilbert of the Schering Corporation. The preparations used were: Oreton (testosteronepropionate), oreton-B (dihydroandrosterone-benzoate), androstenedione, and dehydroandrosterone. All were in seseme-oil solution and, except when otherwise

[1] Contribution No. 83 from the Waterman Institute and No. 278 from the Zoology Department, Indiana University.

[2] The author wishes to acknowledge his indebtedness to the National Youth Administration for technical assistance.

noted, were injected subcutaneously on the side beneath the wing.

The factor used to designate comb size represents the square root of height times length in millimeters ($\sqrt{H \times L}$ mm). This factor is rather satisfactory for comparing comb growth in the chick. Testes were weighed to the nearest tenth of a milligram on a "chainomatic" balance as soon as removed, and the weights as presented in the tables are for both testes.

RESULTS AND DISCUSSION

The investigations of Koch (1936), Meischer and others (1936), Parkes (1936), Deansley and Parkes (1937), and Kochakian (1938) have established that androgens of the testosterone series are more efficient than those of the androsterone series when tested on the capon or castrated rat. Parkes and Kochakian are agreed that the most potent compound of all those tested is the propionate ester of testosterone, and Callow (1936) has indicated that dihydroandrosterone-benzoate is several times more potent than androsterone. The data in table 1 indicate clearly that the baby cockerel reacts somewhat differently to androgens than does the capon or castrated rat.

TABLE 1.—*Comparative effect of androgens on the chick*

Chick No.	Series	Quantity injected	Period of treatment	Comb size[1]	Testes weight
		Milligrams	*Days*		*Milligrams*
No treatment (control)					
65				4.6	16.0
Treated with oreton (Testosterone-propionate)					
26	A	0.625	Fifth to ninth	7.4	13.0
42	B	1.25	do	7.8	11.9
14	C	1.25	Fifth	5.9	12.3
39	D	2.5	First, third, fifth, seventh, ninth	8.8	12.8
10	E	2.5	First	7.0	13.5
Treated with oreton-B (Dihydroandrosterone-benzoate)					
14	F	0.625	Fifth	7.7	11.9
14	G	1.25	do	7.7	12.7
10	H	1.25	First	8.4	10.3
8	I	1.25	First, third, fifth, seventh, ninth	8.6	13.0
20	J	1.25	Fifth to ninth	8.4	12.0
28	K	1.25	do	8.4	
14	L	2.5	First, third, fifth, seventh, ninth	9.1	
Treated with Androstenedione					
14	M	1.25	Fifth to ninth	6.7	
Treated with Dehydroandrosterone					
13	N	1.25	do	6.4	

[1] Designated by square root of height times length in millimeters.

Two things are immediately apparent from the data: (1) Comb size was increased very markedly by injections of male hormones previous to the tenth day, and (2) there was also a uniform inhibition of testicular growth. These points have been partially considered in previous work, reported by the author (1937, 1938a, 1938b), and some additional generalizations may also be made at this time. The ratio between comb growth and testes weight tends to be inversely proportional. The chicks that have the largest combs usually have the smallest gonads. The groups in which injections were begun on the fifth day cannot be compared accurately with those treated from the first day because in the latter groups (series D, E, H, I) the hormones were available over a longer period of time. This greater duration of treatment explains the greater comb growth, but the testes in three of the four groups average heavier than those in the shorter-time series, and this fact suggests the existence of a different threshold response for comb growth and testis inhibition.

Comparison of the oreton and oreton-B series demonstrates that in the chick the propionic ester of testosterone is not the most efficient androgenic substance. Oreton-B produced greater comb growth at the same dosages than oreton (series C and G, B and J, K), and actually in several of the groups a given quantity of oreton-B was nearly as effective as twice that quantity of oreton (series D and I). It was expected, on the basis of the work previously cited, that oreton and oreton-B might be of approximately equal potency. It is obvious, however, that in these experiments oreton-B is much more effective than is oreton as measured by comb growth and, as will be pointed out later, will produce the crowing response earlier.

One of the most striking things about the propionic ester of testosterone was the observation by Parkes that single injections were as efficacious as were multiple doses in the capon or castrated rat. Kochakian's experiments are in disagreement on this point because he found that divided injections produced better response. The data that are presented in this paper support the conclusions of Kochakian, inasmuch as the multiple doses of oreton produced greater comb growth in the chick (series B compared with C, D with E). The most surprising aspect of the problem is the fact that the androgenic effect of one injection of oreton-B is greater than that produced by single injections of oreton (compare C and E with G and H) and compares favorably with the response that followed the administration of oreton-B in divided doses. The dihydroandrosterone-benzoate is, therefore, much more potent in the chick than is the testosterone-propionate.

Dehydroandrosterone and androstenedione elicited less response than the other two androgens, and this finding is in harmony with the data presented from other laboratories. Our results are inadequate at this time to admit a generalization as to the relative effectiveness of the dehydroandrosterone and the androstenedione in the chick.

The differences in the response of the chick and the capon to oreton and oreton-B suggest first of all that the testes modify the reaction. This finding is supported by the observation of Greenwood and coworkers that comb growth of capons having small testicular fragments was much more marked than that in capons receiving the same dosage of androgens. The testes in the White Leghorn cockerel have an average weight on the tenth day of only 16.0 mg, and it seemed unlikely that appreciable quantities of hormone would be secreted by such small immature glands. A study of the normal cycle, reported by Breneman (1938a), supplemented by work on the caponized baby chick indicated, however, that the gonads were releasing some androgenic substance. The possibility of an interaction between this substance and the injected hormone seemed quite likely, and experiments were conducted, therefore, in which various combinations of androstenedione, dehydroandrosterone, oreton, and oreton-B were injected simultaneously. A second possible explanation for the dissimilarity in response between chick and capon should also be considered, namely, that absorption and hydrolysis of the injected hormones in the chick might be different from those of older birds. A partial test of the effect of variation in absorption was made by injecting oreton and oreton-B into the body cavity. Experimental results involving these possibilities are considered in table 2.

The results in table 2 show that when two hormone preparations are given simultaneously the comb is stimulated to greater growth than when only one is injected. This statement applies even though the total quantity of hormone administered in the combination series does not exceed the dosage of a single hormone. With one exception this increased effectiveness was noted in all series, including the combinations of dehydroandrosterone and androstenedione, and most significant was the fact that the oreton-B combinations were uniformly more potent than were the corresponding oreton combinations (series Q and R as compared with S and T). The greater stimulation of comb growth that occurred when oreton-B was injected alone from the first to the fourth days (series V) was the exception encountered in the data. This result appears at

TABLE 2.—*Effect of the combination of androgens injected and the method of injection on comb growth*

Chick No.	Series	Androgen injected	Period of treatment	Size of comb on day indicated: 5	10	15	20	25	30	35
Subcutaneous injections										
			Days							
12	O	0.125 mg androstenedione and 0.125 mg dehydroandrosterone.	Fifth to ninth	...	7.9	11.0	14.7	18.9	22.6	...
12	P	0.125 mg oreton and 0.125 mg oreton-B.	do	...	10.2	15.9	20.2	25.0	29.9	...
12	Q	0.125 mg androstenedione and 0.125 mg oreton-B.	do	...	10.5	16.2	21.1	25.9	31.1	...
12	R	0.125 mg dehydroandrosterone and 0.125 mg oreton-B.	do	...	9.9	15.8	20.4	26.0	30.7	...
12	S	0.125 mg androstenedione and 0.125 mg oreton.	do	...	9.1	12.1	15.8	21.6	28.0	...
12	T	0.125 mg dehydroandrosterone and 0.125 mg oreton.	do	...	8.3	11.1	15.7	21.0	26.6	...
16	U	0.125 mg oreton and 0.125 mg oreton-B.	First to fourth	5.4	10.7	14.5	...	...	...	...
20	V	0.25 mg oreton-B	do	5.8	12.2	17.4	22.1	27.3	32.2	...
Intra-peritoneal injections										
20	W	0.25 mg oreton	Fifth to ninth	...	7.0	10.0	13.8	16.6	18.9	25.6
24	X	0.25 mg oreton-B	do	...	7.6	12.3	15.3	17.6	20.6	27.9
Control										
180	...	...	...	3.6	4.6	7.0	12.3	17.6	19.7	22.5

first to be contrary to the others but may be interpreted as evidence of an early interaction between oreton-B and a testicular androgen. If the testes secrete male hormone at this early age, it would seem logical to expect these substances to be in the testosterone series or in the group of intermediate compounds such as androstenedione or dehydroandrosterone. The data show that treatment from the fifth to ninth days with oreton-B and androstenedione (series Q) was more effective than was similar treatment with oreton and oreton-B (series P) and that oreton-B plus dehydroandrosterone (series R) was nearly as potent as oreton plus oreton-B. These results suggest that the testicular androgen is more nearly comparable to androstenedione or dehydroandrosterone than to testosterone, and this assumption would also explain the greater effectiveness of oreton-B when given alone than when given in smaller quantities with oreton.

The most spectacular phenomenon observed in these experiments was the crowing response, which had been reported in previous work to occur on or about the eleventh day in those series in which injections were begun the fifth day. Crowing was observed on the seventh and eighth days in the series in which oreton and oreton-B were given together (series P), and some of the chicks crowed on the seventh day in the combination group in which injections were begun on the first day (series U). The action of oreton-B alone, however, on and after the first day, as was previously noted, produced greater comb growth than did any of the combination series and crowing also occurred earlier, in this instance on the fifth day (series V). The laboratory assistant reported crowing on the fourth day, but this was not confirmed by the author.

The effect of intraperitoneal injection of oreton or oreton-B does not support the idea that difference in the rate of utilization is important as a primary factor influencing the action of male hormones in the chick. The relative responses of the birds to oreton or oreton-B when injected into the body cavity were the same; oreton-B was again the more potent of the two substances. Some important differences may be observed, namely, that the initial comb growth was not so marked as when the hormones were given subcutaneously, and after the injections ceased the combs continued to grow, but on the twenty-fifth and thirtieth days did not differ markedly from those of the controls. Comb sizes by the thirty-fifth day were again much larger than in the untreated birds. This fluctuation is not typical of the series that received subcutaneous injections, and since comb growth in the intraperitoneal series was less than in any of the other groups, this aspect of the problem should be analyzed further.

The oreton-B combination groups gave maximum comb size at all time periods (series P, Q, R) except for series V noted previously. Averages for the chicks receiving androstenedione plus oreton-B exceeded those for the chicks receiving oreton + oreton-B, and after the fifteenth day the birds injected with dehydroandrosterone + oreton-B were also superior in comb size to the latter group. The question of the continued growth of the comb after the cessation of injections of oreton or oreton-B was considered in previous papers from this laboratory. Two alternative explanations were advanced: (1), That the injected hormone was active throughout the entire period, or (2) that the testes were secreting sufficient androgen to make continued comb growth possible. Tests with baby capons supported the second alternative. The results of the experiments in table 2 also seem to be further confirmation for this latter conclusion because in every instance the greatest growth occurred by the tenth day, and after that time the growth

TABLE 3.—*Gonad weights in control and injected chicks at 35 days of age*

Chick No.	Androgen injected	Period of injection	Gonad weight: Range	Gonad weight: Average
		Days	*Milligrams*	*Milligrams*
No injections (controls)				
20			57.0–158.5	102.9
Subcutaneous injections				
15	Oreton-B	Fifth	82.8–174.7	123.1
8	Oreton-B	Fifth to ninth	86.4–162.5	117.4
12	Oreton + Oreton-B	do	47.0–142.0	96.6
10	Oreton-B	do[1]	58.3–147.4	83.2
13	Dehydroandrosterone	do	32.7–115.8	78.0
14	Androstenedione	do	43.7–118.3	76.6
Intraperitoneal injections				
20	Oreton	do	48.8–167.3	83.8
24	Oreton-B	do	42.3–136.4	90.1

[1] One testis removed on fifth day.

curves fluctuated in a way that is hardly consistent with slow and regular absorption from an oil solution.

A study of the growth curve of the comb for the normal chick shows that the rapid period of growth is from the fifteenth to twenty-fifth days, decreasing slightly after that time. The rate of comb growth in the injected series, with the exception of the series given intraperitoneal injections and with variations in the dehydroandrosterone-androstenedione group, closely parallels the normal curve for this period, but does not show the decrease in rate that is evident in the untreated chicks from the twenty-fifth to thirtieth days.

Our conclusions thus far have presumed the secretion of some testicular androgen by the chick and, if our interpretations are justified, we should find in the testes some explanation for the continued comb growth in the experimental birds. It was reported by Breneman (1937) that testicular weights of chicks which were given oreton, oreton-B, and male-urine extract gave evidence of inhibition, but weights became normal after the injections ceased and in some cases averaged higher than the controls. A similar analysis of the testicular weights in some of the combination series is presented in table 3.

There is great individual variation in gonad weights, especially in month-old birds, and for this reason the data as presented must be used with caution. The general conclusions, however, are apparent. Although the average of 102.9 mg for the controls is probably high because these particular chicks were in less crowded conditions than the experimental birds, it should be noted that the gonads of the chicks injected with oreton-B averaged higher and those of the chicks injected with oreton + oreton-B nearly as high as the gonads of the controls. If maximum allowance is made for variation, it is obvious that the injected and control chicks in these series have gonads of about the same weight with a possibility of the injected birds having the heavier ones. Attention should also be called to the series in which one testis was removed on the fifth day. The average weight of the remaining testis was 83.2 mg on the thirty-fifth day, and this is considerably more than one-half the average for the two testes of the controls. These results show that the pituitary of the injected chicks was not suppressed over the entire 35-day experimental period. The testes in the dehydroandrosterone and androstenedione series, on the other hand, do show very definite evidence of inhibition of some sort, because the average weights are only 78.0 mg and 76.6 mg respectively. Likewise the chicks, that received their hormone intraperitoneally have lower average testes weights than do the controls, which certainly appear to be the result of inhibition.

A correlation of the comb growth with the testes weights affords additional material to explain the difference in results. Maximum comb growth was in the oreton-B series, which received its hormone from the first to the fourth days (Series V). A roughly comparable series given hormone on the fifth day only had testes with the maximum average weight of 123.1. Comb growth in the intraperitoneal and androstenedione-dehydroandrostenedione series paralleled and did not greatly exceed that in the controls and it would seem, therefore, that the greater initial stimulation of the injected hormone was later offset by a lesser quantity of testicular androgen available from the smaller testes.

An histological study of the testes in these various groups should add further information for interpreting these results. Preliminary study has shown active spermatogenesis in some of the oreton-B treated chicks, but in the series given androstenedione and dehydroandrosterone the tubules appear to be inhibited in their development. Final conclusions, however, must await detailed study.

SUMMARY

Single-Comb White Leghorn cockerels were injected, beginning on the first or fifth days after hatching, with oreton (testosterone-propionate), oreton-B (dihydroandrosterone-benzoate), dehydroandrosterone, and androstenedione. The testicular weights in the treated chicks were lower than those in the controls at the close of the injection period (tenth day). Comb size was greatest in the oreton-B series, and crowing occurred as early as the fifth day. The combs continued to grow after injections were terminated. The smallest combs were found in the series that received subcutaneous injections of dehydroandrosterone or androstenedione and intraperitoneal injections of oreton or oreton-B. The combs of these groups, however, exceeded those of the controls at the time injections were terminated and also when the chicks were 30 or 35 days of age.

Various combination injections of the four androgens demonstrated that those series which were given oreton-B along with another hormone had the most marked comb increment. The data support the hypothesis that the chick testis is secreting some androgenic substance or substances and that this androgen probably is more nearly like androstenedione than testosterone-propionate. Testis weights in the groups injected with oreton-B or oreton-B plus oreton were normal or even slightly higher than the controls at 35 days of age. There was evidence, however, that growth of testes was inhibited in the dehydroandrosterone and androstenedione series and possibly also in the groups that received oreton or oreton-B by intraperitoneal injection.

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FORMATION OF THE EGG IN THE OVIDUCT OF BIRDS: OBSERVATIONS ON TURKEYS[1]

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INTRODUCTION

The formation of the egg in birds has been studied intensively by many investigators who have used different techniques. This work has served to clarify many controversial points and to bring to light new information, some of which needs confirmation. Most of the work done has been with the domestic fowl, but sufficient work has been done by Chomkovic (1927) with the duck to indicate that the formation of the duck egg is essentially the same as that of the chicken egg.

One of the interesting points about the formation of the egg in the oviduct is the specificity of the secretion of the different parts. This was first demonstrated by Coste in 1847, who found that in the case of an egg entering the isthmus only the part of the egg actually in the isthmus was covered with a membrane. Pearl and Curtis (1912) demonstrated that only about 40 to 50 percent of the white of the egg is secreted in the albumen-secreting part, a finding that has since been confirmed by Chomkovic (1927) for ducks. Pearl and Curtis (1912), however, considered that protein was added in the isthmus and uterus. McNally (1934) interpreted his data as a confirmation of the work of Pearl and Curtis, but the work of Hughes and Scott (1936) failed to confirm the conclusion arrived at by McNally. Scott, Hughes, and Warren (1937) have shown fairly conclusively that protein is not added to the white except in the albumen-secreting part. Moreover, the data of Asmundson and Burmester (1936, 1938) failed to lend any support to the idea that protein is added in the uterus. It may be assumed, therefore, that water and a little ash are the main contributions of the isthmus and uterus to the white of the egg, as reported by Hansen (1933) and Asmundson and Burmester (1938). The shell membrane is completed in the isthmus, according to Asmundson and Jervis (1933), whereas the shell, including the cuticle, is formed in the uterus. The vagina does not contribute to the formation of the egg, as found by Asmundson (1931, 1933).

There is good reason to believe that the secretion of the anterior portion of the albumen-secreting part differs qualitatively from that of the posterior portion, according to Asmundson and Burmester (1936). Nevertheless, the white of the egg usually has a homogeneous, gelatinous consistency at the time the egg enters the isthmus, there being no indication of a chalaza nor of liquid albumen, according to Hansen (1933), Warren and Scott (1935), and Asmundson and Burmester (1936). Conrad and Phillips (1938) demonstrated that differentiation of the white into chalaza, inner liquid white, firm white, and outer liquid white results from mechanical rotation of the egg in the uterus, and not just from the addition of water and ash. Thus it appears that qualitative differences in the secretion of the various portions of the albumen-secreting part may account for the differences in the proportion of the firm and liquid white, which Lorenz, Taylor, and Almquist (1934) have shown to be inherited. On the other hand, mechanical rotation is necessary to insure the counter-clockwise twisting of the chalazae at the small, and the clockwise twisting of the chalazae at the large, end observed by Almquist (1936). Burmester and Card (1938) have shown that when the part of the oviduct immediately posterior to the funnel is resected, normal chalazae are formed. This part of the oviduct cannot therefore be considered necessary to the formation of the chalazae as claimed by Richardson (1935).

OBSERVATIONS ON TURKEYS

In 1937 work was begun on the formation of the turkey egg. Three eggs were obtained from each of 14 turkey hens. The hens were trapnested every hour. The eggs obtained were placed in an electric refrigerator and were weighed and partitioned within 2 hours of the time they were brought into the laboratory. The shell was separated from the shell membrane and the latter weighed and discarded. The white of the egg was divided into outer liquid, firm white, and inner liquid. The yolk was weighed and discarded. The shell was analyzed for ash and nitrogen. The percentage of solids in the white was calculated from the refractive index, according to the method of Almquist, Lorenz, and Burmester (1932), whereas the nitrogen of the white and of the shell was determined by the Kjeldahl procedure.

Observations on the time interval between eggs indicate that the length of time required for the egg to pass through the oviduct is about the same as for chicken eggs, as reported by Warren and Scott (1935), and others. The time intervals, based on averages of 8 to 23 clutches, were as follows: For two eggs in the clutch, the time interval was 27 hours 42 minutes; three eggs in the clutch, 26 hours 19 minutes between the first two eggs and 27 hours 56 minutes between the second and third eggs; five or more eggs in the clutch, 23 hours 53 minutes to 26 hours 19 minutes between eggs.

Immature eggs were removed from the oviducts

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[1] Most of the analyses were made under the auspices of the Works Progress Administration. Acknowledgment is also made to A. Mecchi, who made a part of the analyses.

of hens at known intervals from the time the hens had laid. The position of the egg in the oviduct was carefully noted. Observation on these eggs indicates that differentiation of the white into separate layers seldom begins until the egg reaches the isthmus. Selected data for laid and immature eggs are summarized in table 1.

In the laid eggs from the four hens, the percentage of the various parts, based on total weight of the egg, varied as follows: Yolk, 30.18 to 34.19; albumen or white, 55.65 to 60.02; shell membrane, 1.41 to 1.55; shell, 8.03 to 8.67. These percentages are within the range of values reported for chicken eggs by Curtis (1914), Jull (1924), Asmundson (1933), Asmundson and Burmester (1936), and Križenecký (1936), except for the shell membrane, which is relatively heavier in the turkey given by Asmundson and Burmester (1936). The length of the part as a percentage of the total length is given in each case. These percentages are as follows: Infundibulum, 14.8 (9.6); albumen-secreting part (magnum) 42.6 (45.0); isthmus, 15.3 (13.4); uterus, 13.5 (16.0); and vagina, 13.6 (16.1). These data indicate that the comparative combined length of the infundibulum and magnum is slightly greater in the turkey. The turkey also has a comparatively long isthmus but a relatively short uterus.

The solids content of the white of eggs laid by the four hens considered in this paper was 12.29 percent. This is a higher value than that calculated from the data given for chickens by Almquist and Lorenz (1933). Romanoff (1929) has given a higher percentage for the solids content of the

TABLE 1.—*Summary of the weights and analyses of the parts of laid and immature turkey eggs*

Laid eggs[1]

Hen No.	Weight of yolk	Weight of egg	White of egg: Weight of solids	White of egg: Weight of nitrogen	Weight of shell membrane	Shell[2]: Weight	Shell[2]: Ash	Shell[2]: Nitrogen
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Percent*	*Percent*
2	28.3	55.1	6.4	8.3	1.39	7.56	....	0.460
5	27.5	52.5	6.4	7.9	1.25	7.49	57.1	0.437
8	27.4	54.5	6.6	8.6	1.41	7.29	55.9	0.463
11	27.4	44.6	5.4	6.9	1.19	6.95	56.2	0.504

Immature eggs

Hen No.	Part of oviduct from which egg was removed	Weight of yolk	White of egg: Weight	White of egg: Weight of solids	White of egg: Weight of nitrogen	Shell membrane and shell[2]: Weight	Shell membrane and shell[2]: Ash	Shell membrane and shell[2]: Nitrogen
		Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Percent*	*Percent*
2	Junction of magnum and isthmus	26.4	32.9	5.8	7.9	0	....	....
5	Isthmus	25.2	42.2	7.3	9.1	0.82	0.848	13.9
8	Half in isthmus and half in uterus	27.0	40.1	6.3	9.2	1.65	2.11	13.6
11	Uterus	27.3	37.6	4.5	6.2	1.87	33.4	6.5

[1] Average values for 3 eggs in each case.
[2] The weight of the fresh shell or shell membrane and shell is given. The percentages of ash and nitrogen are based on the weight of the air-dried shell or shell membrane and shell.

than in the chicken egg. The percentage of shell also appears to be less, on the average, than in the case of chicken eggs, although the thickness of the shells of the two species is about the same. It is of interest in this connection that Jull (1924) found that the heavier chicken eggs had a lower percentage of shell. The decrease in the percentage of shell with increase in the weight of the egg is a result of the changes in the relation of the surface to the volume with changes in the weight of the egg.

In view of the differences between turkey and chicken eggs, it may be well to consider the comparative length of the parts of the oviduct. The following data are based on averages for the four turkey hens included in table 1. The data in parentheses are comparable data for chickens chicken-egg white but a lower figure than the 13.78 percent reported by Hepburn and Mitaglia (1937). The evidence available indicates that the solids content of the white of turkey eggs is higher than that of chicken eggs.

Table 1 brings out several points. In the first place, the weight of the albumen (white) increases after the egg has passed out of the albumen-secreting part. The data in table 1 indicate that after the egg has passed the junction of the albumen-secreting part and the isthmus, the weight of the albumen is more than 50 percent of the weight of the albumen in eggs laid by the same hen. If the quantity of albumen per gram of yolk is calculated for the laid and immature eggs in table 1 and the quantity so obtained for each immature egg computed as the percentage of the corresponding value for laid eggs from the same hen, the results are as follows: Hen 2, 64.1 percent; hen 5, 85.9; hen 8, 74.4; hen 11, 84.0. These results indicate that a large part of the white is secreted after the egg leaves the magnum but that the percentage is probably less than in the case of chickens.

The quantity of solids in the egg white was calculated from the data for percentage of solids. In two of three cases in which the immature eggs had passed the junction of the albumen-secreting part and the isthmus and were in the isthmus or uterus, the immature eggs had less solids than the laid eggs from the same hen. The differences are not significant. The evidence that mineral matter is added in the uterus, referred to previously, suggests that the quantity of solids would be slightly less in the case of eggs removed from the isthmus or those removed soon after they entered the uterus. In view of the small quantity of minerals involved, it might be difficult to demonstrate a difference in the total solids. In the case of the nitrogen, there appears to be no question but that by the time the egg white passes the junction of the albumen-secreting part and the isthmus (table 1), it has acquired all the protein that it has when laid.

Eggs removed from the albumen-secreting part were without shell membranes. In the case of eggs partly in the albumen-secreting portion and partly in the isthmus, only the portion of the egg in the isthmus was covered with a shell membrane. The weights of the shell membranes on eggs in the posterior part of the isthmus or in the isthmus-uterus junction indicate that the shell membrane is completed in the isthmus.

The air-dried shell membrane of the egg in the isthmus (table 1) contained 13.9 percent of nitrogen or 86.9 percent of protein ($N \times 6.25$). It also contained a small quantity of ash, which was also true of other eggs removed from the isthmus. This finding may indicate that some mineral matter is secreted in the isthmus, but the data available cannot be considered conclusive on this point.

It is evident from the data presented in table 1 that the ash content of the combined shell membrane and shell begins to increase as soon as the egg enters the uterus, thus indicating that secretion of the shell begins immediately when the egg enters the uterus.

DISCUSSION

The turkey egg differs somewhat from the chicken egg in the proportion of the different layers of albumen. The proportion of firm albumen is nearly 11 percent less in the turkey egg than in the chicken egg, whereas the former has a relatively larger quantity of inner and outer liquid albumen. Nothing in the data available suggests a reason for this difference, although the percentage of firm albumen may differ in eggs from different strains of turkeys just as in the case of chickens, as reported by Lorenz, Taylor, and Almquist (1934). On the other hand, the higher percentage of shell membrane and lower percentage of shell on turkey eggs as compared with chicken eggs appear to be due to a difference in the comparative length of the isthmus and uterus in these two species. The albumen of the turkey egg also has a higher average percentage of solids than the albumen of chicken eggs. This difference in the laid eggs of the two species is apparently explained by the secretion of relatively more of the albumen in the albumen-secreting part and the addition of relatively less water with its contained minerals after the egg leaves the albumen-secreting part in turkeys as compared with chickens.

The data for total solids and total nitrogen in the albumen of eggs removed from the isthmus and uterus indicate that all the protein in the albumen is secreted in the albumen-secreting part. Considerable water is added to the albumen after the egg leaves the albumen-secreting part, but the quantity is apparently relatively less than in the case of chickens. This secretion of shell onto the shell membrane begins immediately on the entrance of the egg into the uterus. At the same time minerals dissolved in the water presumably enter the albumen of the egg. The shell membrane thus stops the addition of protein to the albumen but not the addition of solids in the form of minerals. The quantity of minerals in the albumen of laid eggs is so small, however, that they have little effect on the total solids.

From the foregoing there appear to be three differences between the eggs of turkeys and chickens, namely, percentages of shell, shell membrane, and solids of the albumen. The first two apparently depend on differences in the relative size of the isthmus and uterus of the two species. The third difference may also be due to differences in the uterus of the two species since most of the water added after the egg leaves the albumen-secreting part is probably secreted in the uterus.

SUMMARY

The formation of the turkey egg was investigated by obtaining three or more laid eggs from each of 14 turkey hens within an hour of the time they were laid. The eggs were weighed, partitioned, and the parts weighed, the solids and nitrogen content of the albumen determined, together with the nitrogen and ash content of the shell. Similar data were obtained for eggs removed from the posterior part of the albumen-secreting part, the isthmus, and the uterus.

For turkeys, the time interval between laid eggs is about the same as for chickens. The turkey egg has a relatively lighter shell, a relatively heavier shell membrane, and a higher percentage of solids in the white than has the chicken egg. These differences appear to be due to differences in the relative length of the parts of the oviduct, particularly the isthmus and uterus.

The results of observations on eggs removed from the oviduct agree in general with those obtained for chickens. In the case of albumen (egg white), all the protein in the egg is secreted in the albumen-secreting part; water is added to the white after the egg leaves the albumen-secreting part; ash is added to the albumen in the uterus but some may also be added in the isthmus; differentiation of the albumen into layers usually begins in the isthmus and is completed in the uterus. The shell membrane is formed in the isthmus. The shell is formed in the uterus; secretion begins immediately on the entry of the egg into the uterus.

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RATE OF EGG-SHELL FORMATION IN THE HEN

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INTRODUCTION

It is well known that deposition of the calcareous shell of a hen's egg occurs in the uterus. Asmundson and Jervis (1933) and Asmundson and Burmester (1936, 1938) have clearly demonstrated that resection of a part of the uterus results in a reduction in the quantity of shell. Although the time that the egg remains in the uterus has been rather accurately determined, as reported by Warren and Scott, (1935a, b) information on the rate of calcareous-shell deposition is lacking.

The plan of this experiment was to compare shells of eggs prematurely expelled from the uterus with shells of eggs laid by the same hen.

METHODS AND MATERIAL

The White Leghorn hens and the crossbred hens (from White Leghorns and Barred Plymouth Rocks) used in this experiment were kept in individual hen batteries that provided convenient means of handling the birds. Data from two to five eggs laid by each hen were used for comparison with data from manually expelled eggs of the same hen.

Oviducal eggs can first be detected by palpation about 3 hours after the previous egg has been laid or when the egg is about to enter the isthmus, according to Warren and Scott (1935b). Two hours later the egg enters the pouchlike part of the uterus. By the use of this information and technique the time at which oviducal eggs entered the uterine pouch was determined. Palpations were made every 15 minutes; hence time measurements are subject to an error of $\pm 7\frac{1}{2}$ minutes.

All eggs were weighed, broken, and their contents measured for studies to be reported elsewhere. The shells (with membrane) were carefully washed, dried at 110° C. in a tared crucible, and then ignited at 850° C. to convert the calcium carbonate of the shell to calcium oxide. The ash was weighed after having cooled to room temperature in a desiccator. In each case the manually expelled egg was taken from the uterus at the designated time by anesthetizing the bird with 0.5 to 0.7 cc of nembutal and applying pressure to the anterior end of the uterus and egg in such a manner that the egg was forced to the outside without breaking its membranes.

RESULTS AND DISCUSSION

Data were obtained on 67 eggs manually expelled from the uteri of 42 hens.

The extent of calcium carbonate deposition in the manually expelled eggs was expressed by the equation

$$D = \frac{N_l C_i \times 100}{\Sigma C_l}$$

in which D designates the percentage of deposition, C_i the weight of $CaCO_3$ of the manually expelled egg shell, $\Sigma\ C_l$ the summation of the weights of $CaCO_3$ of the laid-egg shells analyzed, and N_l the number of laid-egg shells analyzed. All data were grouped with respect to hours in the uterus, and the means for each period are given in table 1.

A curve, drawn by free hand from the individual data points, is shown as the broken line in figure 1. The data indicate that shell deposition proceeds slowly during the first 3 hours in the uterus. The mean percentage of deposition (D) of 5 eggs at the 3-hour period was only 3.51 percent (table 1). The rate increases rapidly after the third hour and apparently assumes a constant figure by the fourth hour or thereabouts. This rate is maintained until the twentieth hour, or presumably the time of laying. Although the data points are somewhat scattered, nothing other than a straight line is indicated after the fourth hour.

An equation expressing the function of the linear portion of the curve was derived and found to be

$$y = 5.644x - 16.617$$

in which y is the percentage deposition (D) and x the number of hours in the uterus. The constants for this equation were derived by the method of least squares from the data of eggs held in the uterus 4 to 20 hours. The graph of this equation is shown as the continuous line in figure 1. According to the equation, 5.64 percent of the

TABLE 1.—*Summary of the calcium carbonate in shells of laid eggs and eggs taken from the uterus after various intervals*

Pefiod in uterus (hours)	Eggs	Mean weight of $CaCO_3$ in shell of—		Proportion of $CaCO_3$ in shell of manually expelled egg[1]
		Laid egg	Manually expelled egg	
	Number	*Grams*	*Grams*	*Percent*
1	5	4.759	0.025	0.53
2	5	4.687	.130	2.77
3	5	4.694	.165	3.51
4	5	5.136	.458	8.92
5	5	4.883	.494	10.11
6	5	4.955	.696	14.04
7	5	4.675	1.095	23.43
8	1	4.129	1.371	33.20
9	6	5.066	1.666	32.90
10	6	4.746	2.039	42.95
11	5	4.884	2.030	41.56
12	3	4.927	2.268	46.02
13	3	4.801	2.723	56.72
15	3	5.544	3.846	69.36
16	2	4.489	3.674	81.85
17	2	4.973	3.610	72.59
19	1	5.683	5.338	93.93
20	1	5.375	5.241	97.50

[1] Based on quantity in shells of laid eggs.

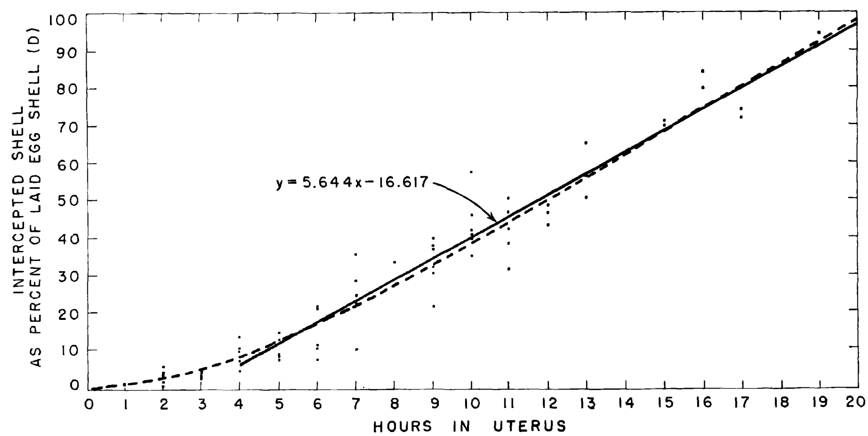

FIGURE 1.—Rate of calcium carbonate deposition in the uterus of the hen. (Broken line represents the curve drawn by free hand from all the individual data points; solid line is the function of the above linear equation, which was derived from the data on eggs held in the uterus 4 to 20 hours.)

shell would be laid down every hour after the fourth and be completed after a sojourn of 20.7 hours in the uterus. This figure is identical with that obtained by Warren and Scott (1935a) (20 hours 40 minutes) for the time that the egg remained in the uterus of anesthetized birds. These data therefore indicate that the rate of calcium carbonate deposition established after 4 hours remains undiminished until about the time of laying.

The point of inflexion of the curve (fig. 1) which occurs between the third and fourth hours is of particular interest. When the egg enters the uterus the shell membrane fits loosely about the egg. Within 2 to 3 hours the membrane becomes taut owing to an increase in the egg contents. Although some discrepancy in time exists, a relationship between plumping and increase in rate of shell deposition is suggested. On the other hand, Scott (1938) showed that the egg does not acquire its full quota of white until after it has been in the uterus 5 to 6 hours, thus indicating that the high rate of deposition prevails before the egg has attained its maximum size. However, size may not be an important factor at least for the stimulation of shell deposition, since Pearl and Surface (1909) found that a calcareous shell was deposited on feces when the latter were made to pass through the uterus by an operative alteration. The extent or rate of this deposition was not measured.

It should be remembered that the rate-of-shell-formation curve presented herein is a composite of data taken from one or two uterine eggs of 42 hens. It is conceivable that a great variation may be found not only among curves of individual hens but also among the shell-formation curves of individual eggs of the same hen, and that the types of curves obtained from individual eggs may be quite different from the composite curve. A radiographic method of measuring the rate of calcium deposition during shell formation is being investigated. It is obvious that more information must be accumulated before the physiology of egg-shell formation is understood.

SUMMARY

The rate of calcium carbonate deposition in the uterus was measured by analyzing the shells of eggs which were allowed to remain in the uterus for 1 to 20 hours. The time at which the egg entered the uterus was determined by digital palpation. The uterine eggs were obtained at the designated time by anesthetizing the bird and applying pressure on the uterus and egg in such a manner that the eggs were forced to the outside without breaking their membranes. Data on the shells of the manually expelled eggs were compared with the mean of the data obtained from two to five eggs laid shortly before or after the expelled eggs were formed.

Data on the shells of 67 eggs manually expelled from the uteri of 42 birds indicate that the rate of calcium carbonate deposition is relatively slow during the first 3 hours. The rate then increases and quickly assumes a constant figure which is maintained until the twentieth hour, or the time of laying.

The equation $y = 5.644x - 16.617$, in which y is the percentage of calcium carbonate deposition and x the number of hours in the uterus, expresses the rate of shell formation between the fourth and twentieth hours in the uterus.

Since the plumping of uterine eggs and the increase in the rate of shell deposition occur at about the same time, it is suggested that the plumping of the egg may act as a stimulus for maximal rate of shell deposition.

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EFFECT OF RESECTION OF THE ALBUMEN TUBE ON SECRETION OF EGG WHITE[1]

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INTRODUCTION

The surgical approach to a study of the physiology of egg production was first used by Pearl and Surface (1908), who succeeded in removing a section of the albumen tube without impairing the function of the oviduct. They concluded that egg size was not affected by such an operation, but the subsequent papers of Asmundson and Jervis (1933) and Asmundson and Burmester (1936, 1938) have indicated that the weight of any part of the egg is conditioned by the secretory area of the division of the oviduct in which that part is elaborated. An experimental reduction in the weight of the albumen region, isthmus, or uterus is reflected in the weight of the white, shell membranes, or shell, respectively.

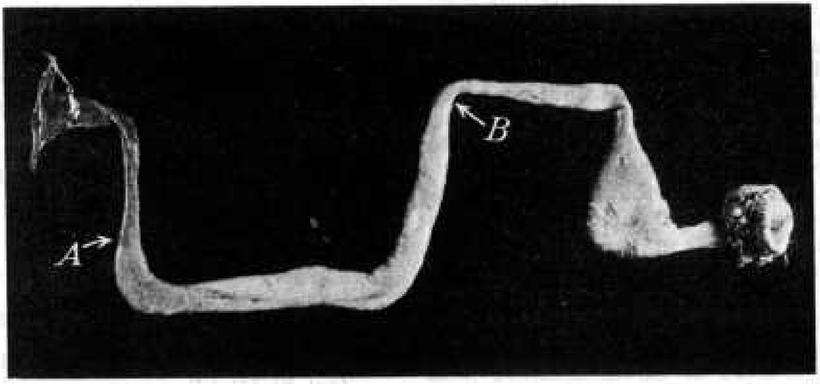

Figure 1.—Oviduct of the domestic hen. A–B, magnum.

METHODS AND MATERIAL

This study was undertaken to obtain more precise information concerning the quantitative relationship between the quantity of resected tissue and the resulting decrease in egg weight. Mature females which presumably had attained normal or constant egg size were used, and the operative technique was that developed by Asmundson and coworkers.

All operations were performed on that portion of the oviduct shown between A and B of figure 1. The resected portion of the albumen tube was measured and weighed at the time of removal. At the conclusion of the experiment each hen was killed, when in laying condition, and her oviduct was measured and weighed. This procedure made it possible to determine the exact site of the operation and to obtain a reasonably accurate estimate of the percentage of the albumen tube which had been removed.

Data were obtained on a minimum of five eggs for each hen in advance of the operation in order to have a standard with which to compare the postoperative eggs. Data on hens that laid fewer than five eggs following the operation were excluded from the tabulations. A few hens which died or ceased to lay before they could be killed for observation were also excluded.

In the performance of the operations, silk ligatures were applied to the blood vessels of the two ligaments wherever necessary to reduce hemorrhage. The limits of the area to be resected were marked by hemostats and cut on a bias. After resection, the two free ends of the oviduct were anastomosed by a continuous suture with 000 nonboilable gut.

RESULTS

The operations were grouped into three arbitrary classes, A, M, and P, depending on the location of the segment removed. For type A, the anterior margin of the resected duct must have extended into the first 25 percent of the magnum, but the posterior margin not beyond the 50 percent division point. For type P, the posterior margin of the resected tissue must have extended into the lower 25 percent of the magnum, but the anterior margin not beyond the 50 percent division point. All other operations were called type M.

[1] Adapted from a thesis submitted by the senior author to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of doctor of philosophy.

Data are available on 16 individuals, 4 of which belong to type A, 7 to type M, and 5 to type P. The length of the albumen tube following the operation, as determined at autopsy, the estimated length of the albumen tube before the operation, the size of the segment resected, and the estimated percentage of the magnum removed are given in table 1.

Data concerning the number of eggs, the mean weight of the whole egg and for each of its parts before and after the operation, and the means for

TABLE 1.—*Length of the albumen tube before and after the operation and the absolute and relative amount removed by the operation*

Type of operation[1]	Hen No.	Length of albumen tube— Before operation	Length of albumen tube— After operation	Size of resected piece Weight	Size of resected piece Length	Proportion of albumen tube resected— By weight[2]	Proportion of albumen tube resected— By length
		Centimeters	*Centimeters*	*Grams*	*Centimeters*	*Per cent*	*Per cent*
A	607	33.0	24.6	5.24	8.4	23.16	25.45
	629	33.3	25.0	5.79	8.3	34.70	24.90
	44	35.2	29.2	3.35	6.0	19.03	17.05
	646	27.7	24.0	1.70	3.7	12.79	13.36
	Mean	32.3	25.7	4.02	6.6	22.42	20.19
M	723	28.1	15.1	7.87	13.0	42.06	46.26
	632	33.9	24.6	6.19	9.3	33.03	27.43
	615	27.3	20.3	4.05	7.0	25.90	25.60
	644	28.9	21.9	4.96	7.0	24.64	24.22
	655	38.6	31.0	6.71	7.6	26.70	19.70
	641	37.3	30.8	3.38	6.5	18.49	17.43
	730	41.5	36.0	3.17	5.5	14.11	13.25
	Mean	33.7	25.7	5.19	8.0	26.42	24.84
P	755	26.6	18.1	5.69	8.5	51.03	31.95
	740	32.8	25.3	5.49	7.5	26.04	22.86
	643	28.7	22.5	2.33	6.2	17.27	21.60
	746	37.3	31.8	4.16	5.5	18.07	14.05
	741	40.3	34.7	3.44	5.6	19.08	13.90
	Mean	33.1	26.5	4.22	6.7	26.30	20.87

[1] Type A, confined to first half of duct and extending into the first fourth of magnum; type P, confined to last half of duct and extending into the last fourth of magnum; type M, all others.

[2] Computed from the size of the resected piece and the size of the albumen tube as determined at autopsy.

the various types of operations are given in table 2. For operations of type A and type M, the mean preoperative and postoperative yolk weights were almost identical, whereas in type P the postoperative yolks were reduced by about 0.9 gram.

In two instances the eggs laid after the operation were larger than those laid before; in the other 14 cases the postoperative eggs were reduced in size.

Data for the change in weight of white are given in condensed form in table 3. For each of the three types of operation, the hens are listed in the order of the percentage of the magnum resected.

The absolute quantity of white decreased after the operation in 14 cases and increased slightly in 2 cases. For all eggs laid before and after the operation, on which data are available, the average decrease in grams was 1.35 ± 0.54, 5.76 ± 0.59, and 4.44 ± 0.46, respectively, for operations A, M, and P (table 4). These differences are statistically significant for types M and P.

Since an analysis of the rate of white secretion[2] has indicated that the rate is constant for the full length of the albumen tube, the removal of equivalent segments from different levels should have the same influence on white secretion. The results for operations M and P are entirely in accord with this point of view, when due allowance is made for the slightly greater amount of the duct resected in operations of type M. We have no explanation for the apparent discrepancy of group A, other than the small number of individuals subjected to this type of operation. In general, there is a direct relationship between the length of the resected segment and the decrease in the quantity of white.

Asmundson and Burmester (1936) report a qualitative difference in the white following resection, depending on the site of the operation. Operations confined to the anterior part of the albumen region decreased the thin white with no appreciable effect on the firm white, whereas segments removed from the center of posterior regions reduced the firm white with no influence on the less viscous white. In general, the results presented in table 4 substantiate their findings. The differences and probable errors are for all eggs laid before and after the operation. Operations of types A and M significantly reduced the absolute quantity of thin white, whereas types M and P reduced the quantity of firm white.

The significant increase in the firm white following the resection of the anterior part of the albumen tube is interesting. The data were analyzed on the basis of the individual bird to determine whether the difference could be accounted for by the record of a single individual. The results (table 5) show that all birds varied in the same direction.

In studying the resistance of raw egg white to proteolytic digestion, Hughes, Scott and Antelyes (1936) concluded that most of the inhibitory substance (antienzyme) responsible for this resistance on the part of egg white was to be found in the inner thin fraction. The site of type A operations varied but little and this may explain the uniformity in trend. It is difficult to bring the conclusions of Hughes and coworkers in line with the results obtained from the operations conducted on the anterior region of the tube. If the inhibitory substance is located in the inner thin fraction, then resection of the anterior region, which gives rise to this fraction of white, should reduce the quantity of the antienzyme and hence

[2] Unpublished data.

TABLE 2.—*Weights of eggs and their component parts before and after resection of the albumen tube*

Type of operation[1]	Hen No.	Pre-operative eggs	Post-operative eggs	Weight of egg		Weight of yolk		Weight of white		Weight of Shell	
				Before operation	After operation	Before operation	After operation	Before operation	After operation	Before operation	After operation
		Number	*Number*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
A	607	5	8	57.02	55.64	18.04	18.45	32.91	30.91	6.07	6.29
	629	6	11	52.71	49.26	16.10	16.54	30.55	26.84	6.06	5.89
	44	5	13	61.02	60.52	19.08	20.15	34.68	33.06	7.26	7.31
	646	5	6	50.61	50.49	16.70	15.35	28.05	28.91	5.87	6.23
	Mean	5.3	9.5	55.34	53.98	17.48	17.62	31.55	29.93	6.32	6.43
M	723	10	8	54.84	34.97	17.10	17.08	31.69	13.60	6.05	4.29
	632	5	12	54.72	46.25	15.47	14.93	32.97	25.51	6.28	5.80
	615	5	5	51.60	46.83	17.02	15.61	29.02	25.73	5.57	5.49
	644	5	8	51.74	48.53	16.70	15.10	29.25	27.39	5.80	6.04
	655	6	10	53.11	50.74	14.69	15.03	33.00	29.53	5.42	6.18
	641	10	11	49.22	48.40	15.19	16.79	28.77	26.42	5.26	5.20
	730	5	9	[illegible]	57.64	17.11	18.91	33.34	32.12	6.18	6.62
	Mean	6.6	9.0	53.12	47.62	16.18	16.21	31.15	25.76	5.79	5.66
P	755	10	5	59.00	46.85	17.19	16.42	34.53	25.39	7.28	5.05
	740	10	10	59.22	48.87	18.56	16.91	33.50	26.94	7.16	5.02
	643	5	11	53.45	47.30	17.23	16.32	29.95	24.81	6.27	6.17
	746	5	11	55.87	56.82	18.27	17.83	31.89	33.02	5.71	5.96
	741	5	9	58.20	54.83	17.72	17.10	34.16	31.45	6.32	6.28
	Mean	7.0	9.2	57.15	50.93	17.79	16.92	32.81	28.32	6.55	5.70

[1] See footnote 1. table 1.

reduce rather than increase the firm fraction of white.

Since complete recovery with satisfactory postoperative laying performance following resection occurs in but a small percentage of cases, a different type of operation was performed on one hen (No. 32). The oviduct was cut just posterior to the junction of the infundibulum and the magnum, and also just anterior to the junction of the latter with the isthmus. The resected segment was permitted to remain in the body cavity with both ends open and with the ligaments, blood supply, and innervations intact. The upper and lower parts of the oviduct were then anastomosed in the usual way. The relation of the isolated loop to the functional oviduct is indicated in figure 2. (In preparing the specimen for photography, the ligaments were dissected away.) The isolated loop represented 82.2 percent by length and 82.6 percent by weight of the total magnum.

Data concerning the eggs laid before and after the operation are given in table 6.

The weight of white was reduced by 72 percent in the postoperative eggs. Of the total white present, 46 percent was firm in nature.

It is interesting to note that although a membranous egg was found in the uterus at autopsy, white secretion as determined macroscopically had not been initiated in the isolated loop by the recent passage of the ovum through the remaining

TABLE 3.—*Average decrease in white following the resection of the albumen tube and the relation of the proportion of the albumen tube resected to the percentage of decrease*

Type of operation[1]	Hen No.	Weight of white				Proportion of albumen tube resected
		Before operation	After operation	Loss (−) or gain (+)		
		Grams	*Grams*	*Grams*	*Percent*	*Percent*
A	607	32.91	30.91	− 2.00	− 6.08	35.45
	629	30.55	26.84	− 3.71	−12.14	24.91
	44	34.68	33.06	− 1.62	− 4.67	17.05
	646	28.05	28.91	+ 0.86	+ 3.07	13.36
	Mean			− 1.48	− 4.96	20.19
M	723	31.69	13.60	−18.09	−57.08	46.26
	632	32.97	25.51	− 7.46	−22.63	27.43
	615	29.02	25.73	− 3.29	−11.34	25.60
	644	29.25	27.39	− 1.86	− 6.36	24.22
	655	33.00	29.53	− 3.47	−10.52	19.70
	641	28.77	26.42	− 2.35	− 8.17	17.43
	730	33.34	32.12	− 1.22	− 3.66	13.25
	Mean			− 5.39	−17.11	24.84
P	755	34.53	25.39	− 9.14	−26.47	31.95
	740	33.50	26.94	− 6.56	−19.58	22.86
	643	29.95	24.81	− 5.14	−17.16	21.60
	746	31.89	33.02	+ 1.13	+ 3.54	14.05
	741	34.16	31.45	− 2.71	− 7.93	13.90
	Mean			− 4.48	−13.52	20.87

[1] See footnote 1, table 1.

TABLE 4.—*Average weight and the volume of thin and firm white of preoperative and postoperative eggs*

Type of operation	Weight of total white			Volume of thin white			Volume of firm white		
	Before operation	After operation	Loss (−) or gain (+)	Before operation	After operation	Loss (−) or gain (+)	Before operation	After operation	Loss (−) or gain (+)
	Grams	*Grams*	*Grams*	*Cubic centimeters*	*Cubic centimeters*	*Cubic centimeters*	*Cubic centimeters*	*Cubic centimeters*	*Cubic centimeters*
A	31.50 ± 0.39	30.15 ± 0.37	−1.35 ± 0.54	13.9 ± 0.47	9.9 ± 0.40	−4.0 ± 0.62	17.2 ± 0.39	20.6 ± 0.45	+3.4 ± 0.60
M	30.99 ± .24	25.23 ± .54	−5.76 ± .59	11.3 ± .32	7.6 ± .27	−3.7 ± .42	19.6 ± .36	17.0 ± .44	−2.6 ± .57
P	33.14 ± .29	28.70 ± .36	−4.44 ± .46	11.8 ± .54	10.8 ± .26	−1.0 ± .60	20.7 ± .65	17.4 ± .79	−3.3 ± .79

TABLE 5.—*Average volume of firm white in eggs of individual hens before and after operation*

Hen No.	Volume of firm white	
	Before operation	After operation
	Cc	*Cc*
646	16.3	18.7
607	19.9	24.5
44	16.0	20.9
629	16.8	18.5

TABLE 6.—*Data on preoperative and postoperative eggs of hen 32*

Type of egg	Eggs	Weight of—				Volume of—		
		Total eggs	Yolk	White	Shell	Thin white	Firm white	Total white
	Number	*Grams*	*Grams*	*Grams*	*Grams*	*Cc*	*Cc*	*Cc*
Preoperative	10	60.26	19.03	34.70	6.54	12.45	21.45	33.90
Postoperative	4	34.76	21.36	9.69	3.71	4.85	4.15	9.00

divisions of the intact duct. Thus it would seem that that phase of the secretory phenomenon associated with the extrusion of white into the lumen of the duct is normally conditioned by the presence of the yolk. Further experiments are in progress to study the physiology of the isolated loop.

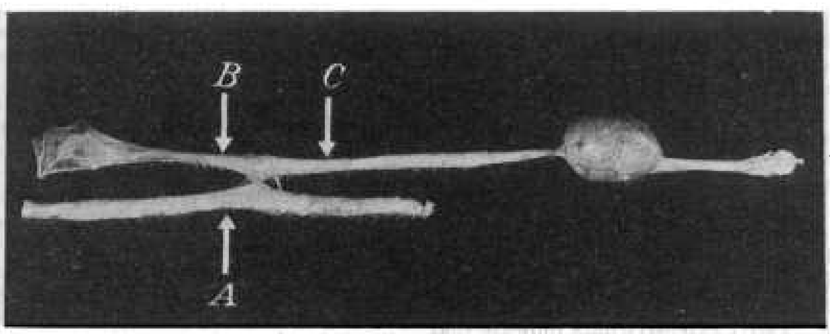

FIGURE 2.—Operation performed on hen 32: A, isolated loop; B–C, intact magnum.

SUMMARY

Three types of operations were performed on the albumen-secreting region of the oviduct. Resection of the anterior (type A), middle (type M), and posterior (type P) regions reduced the absolute quantity of albumen secreted. All differences were statistically significant except for type A operations. In general, the larger the piece resected the greater was the reduction in albumen.

Operations of types A and M significantly reduced the absolute quantity of thin white, whereas types M and P significantly reduced the quantity of firm white.

A significant increase was observed in the firm white of eggs laid after operations on the anterior part of the albumen-secreting region. This was true for each of the four hens subjected to this type of operation.

An operation is described in which the resected segment of the oviduct was allowed to remain in the body cavity with the ligaments intact. This type of operation permits the resection of relatively large segments of the duct.

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PLUMAGE REACTIONS TO THEELIN IN THYROIDECTOMIZED FOWL

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Experiments are in progress at the Agricultural Research Center, Beltsville, Maryland, for the accurate evaluation of the several endocrine factors involved in the determination of plumage types, primarily with the view of utilizing plumage reactions as measures of specific endocrine levels in domestic fowl. Among relationships under investigation is that between thyroxine (thyroid substance) and theelin (the chief endocrine product of the ovary, or the "female hormone" of the earlier literature). The roles of these endocrines are of particular interest in view of the theory proposed by Greenwood and Blyth in 1929. These authors, after careful analysis of plumage changes in the Brown Leghorn following thyroidectomy and equally careful consideration of prior work on the effects of hyperthyroidism on plumage, came to the conclusion that "the female thyroid functions at a higher level than that of the male." Greenwood and Blyth believed this greater activity of the female thyroid to be "dependent in some manner on the gonad and . . . not a primary sex factor."

In the domestic fowl it is commonly assumed that the level of thyroid activity determines, within limits and as a rule, the level of basal metabolism. Fairly extensive data indicate that the basal metabolism of the male is generally higher than that of the female, as is emphasized by Riddle (1932). If it is assumed, then, that basal metabolism depends on the level of thyroid activity, the male should have a higher level of thyroid functioning than the female, which sex difference is the reverse of that indicated by Greenwood and Blyth.

It is not necessary to discuss here the probable participation of endocrine factors other than the thyroid in determination of relative levels of basal metabolism in the sexes. If plumage reactions only are considered, it is conceivable that theelin may effect, directly or indirectly but in any event independently of thyroid stimulation, plumage modifications similar to those known to follow administration of thyroid to the male or the capon. There is the further possibility that an unchanged or even a lowered level of thyroid functioning may be more effective in bringing about characteristic plumage modifications in the presence of theelin than in the absence of this hormone. Experiments to test these possibilities are reported in this paper. Results in hand at this writing indicate that there is some degree of parallelism or synergism in the action of theelin and thyroid with respect to plumage reactions.

PLUMAGE TYPES

The administration of theelin in appropriate concentrations to either the male or the capon of dimorphic breeds causes the appearance of plumage resembling that of the female of the same breed in every particular. Various phases of this resemblance have been studied by Juhn and Gustavson (1930), Juhn, Faulkner, and Gustavson (1931), Lillie and Juhn (1932), Danforth (1933), and others. Administration of thyroid substance (or thyroxine) at a proper level likewise transforms the plumage of the male or the capon into the typical female type so far as size, shape, and structural differentiation of feathers are concerned, as has been reported by Torrey and Horning (1922), Cole and Reid (1924), Horning and Torrey (1927), Zawadovsky and Rochlin (1928), and Danforth (1933). Thus, excluding color reactions, in plumage areas where male and female feathers are structurally similar, as in the breast tracts, neither thyroxine nor theelin has any appreciable effect at physiological levels. In plumage areas where male and female feathers are differentiated in size, shape, and extent of barbulation, either theelin or thyroxin in appropriate concentrations causes the appearance of feathers resembling the corresponding feathers of the female.

In males of genetically reactive birds, thyroid administration causes an extension of melanization into feather areas not otherwise so pigmented; this effect appears to be very general. Thyroid alone, however, may be incapable of producing the characteristic color patterns of the female. In the Brown Leghorn, for example, the stippled pattern of the female saddle feather appears only in the presence of the female hormone.

Plumage modifications following thyroidectomy are in general the reverse of those resulting from supranormal concentrations of thyroid substance, as has been demonstrated by Greenwood and Blyth (1929), Parkes and Selye (1937), and unpublished results at Beltsville based on some 60 birds. The feathers of most body areas become narrower, longer, and more pointed than are the corresponding normal feathers of either sex; barbulation is restricted to varying degrees in the several plumage tracts. These effects are notable in breast feathers of either sex, which become strikingly similar to saddle feathers of the normal male or the capon in essential particulars. In at least certain breeds, for instance, the Brown Leghorn, thyroidectomy is followed by marked restriction of melanization. In the breast areas, for example, the normally black feathers are replaced by a brick-red plumage lacking all traces of melanin.

EXPERIMENTAL

In view of differing experimental conditions and diverse effects following injection of theelin into thyroidectomized birds, individual records are presented briefly. Theelin in oil (1 mg of theelin per milliliter of oil) has been used in all injections.

Brown Leghorn capon No. 8840. Thyroids intact; this bird used as a control for theelin-injected thyroidectomized birds. Theelin injected from November 10, 1938, through November 26, 1938; 100 gamma daily.

The plumage of this bird approximated closely the type of the normal female during entire period of theelin injections, although stippling in the wing secondaries was somewhat coarser than is the usual female pattern.

White Leghorn male No. 6751. Thyroidectomized August 1, 1938. Subcutaneous injections of theelin, 100 gamma daily, begun November 10, 1938, and terminated December 5, 1938. Feathers grown following thyroidectomy and prior to theelin injections were of extreme athyroidic type. Examination of thyroid sites following termination of theelin injections failed to reveal any trace of thyroid tissue.

Both saddle and breast feathers were modified in the direction of typical female feathers in size, shape, and extent of barbulation. Color remained unchanged from the normal in either thyroidectomized or theelin-injected thyroidectomized White Leghorns.

Brown Leghorn capon No. 8841. Thyroidectomized October 20, 1938. Subcutaneous injections of theelin, 100 gamma daily, begun November 10, 1938, and terminated December 5, 1938. Feathers grown following thyroidectomy and prior to theelin injections indicated incomplete removal of thyroid glands. Examination of thyroid sites following termination of theelin injections disclosed piece of thyroid tissue the size of which was approximately one-sixteenth that of the mass of normal thyroids.

Theelin injections brought about almost complete transformation of both breast and saddle feathers to normal female types. These changes occurred more gradually than in the case of the control bird (Brown Leghorn capon 8840), but more abruptly and extensively than in athyroidic White Leghorn 6751. Color and color patterns of modified feathers approximated closely those of the typical Brown Leghorn female plumage.

Brown Leghorn capon No. 8852. Thyroidectomized October 20, 1938. Subcutaneous injections of theelin, 300 gamma daily, begun November 10, 1938, and terminated December 5, 1938. Feathers grown following thyroidectomy and prior to theelin injections were of extreme athyroidic type. No trace of thyroid tissue could be found on exploratory examination following termination of theelin injections.

The theelin-modified breast feathers were relatively broad and short, with blunt apexes and barbs at an unusually obtuse angle with the shaft. Barbulation was extensive, but barbules were slender and attenuated, apparently lacking barbicels, and no solid vane surface was formed as in normal feathers. The posterior breast feathers were markedly retarded in growth rate, reaching a length of less than 2 cm in 26 days under theelin injections. Molt of posterior breast feathers began on twenty-fifth day of injections; this molt spread rapidly to anterior levels of the tract.

Feathers in various parts of the breast tracts were on the point of emergence at the time theelin injections were begun. These feathers, particularly those of the posterior breast tract, carried a dark spot or band at or just below the feather apex. Below this melanic area such feathers became markedly blanched and remained so until molted. No trace of the typical brick red of the athyroidic feather appeared in feathers of the posterior breast tracts at any time during theelin injections.

Saddle feathers showed, in general, much more moderate effects than did breast feathers.

Following cessation of theelin injections, a new generation of posterior breast feathers promptly appeared. These were slate black for a distance of 2 or 3 cm from their apexes, and barbulation in these areas was much more intense than in corresponding areas of athyroidic feathers. While these feathers were still coming in black (3 weeks following cessation of injections), a large cyst was discovered on the right leg, below the site of injections. This was filled with oil and detritus, the quantity of oil being approximately 6 to 8 ml. After removal of the cyst, growing feathers assumed a pigmentation resembling, except for dullness, the red of the athyroidic feather. No solidly black areas subsequently appeared, although traces of black continued to replace red in the neighborhood of the shaft.

Rhode Island Red male No. 6748. Thyroidectomized June 9, 1938. Subcutaneous injections of theelin, two-thirds milligram daily, begun August 9, 1938, and terminated August 11, 1938. Feathers grown following thyroidectomy and prior to theelin injections were of athyroidic type but not so extreme as in athyroidic Leghorns. No trace of thyroid tissue was found in former sites following termination of injections.

In both breast and saddle feathers theelin caused a marginal extension of visible barbulation, not equally clean-cut in all feathers, but clearly coinciding with the period of injections in at least certain feathers. In some saddle feathers this extended zone of barbulation showed a definite restriction some distance proximal to its level of appearance, producing much the effect described by Lillie and Juhn (1932) and others as characteristic of relatively short-time injections of theelin into the male or the capon with intact thyroids.

DISCUSSION

In several respects the foregoing records indicate theelin effects paralleling or complementing the known effects of thyroid in males or in capons with intact thyroids. Thus in partially thyroidectomized capon 8841 theelin induces much the same reactions observed in the normal capon, No. 8840. Since the hypothyroid bird carried only one-sixteenth of the normal thyroid mass, one may conclude that this quantity of tissue can function in the presence of theelin at a higher level of activity than can the thyroids of the normal capon in the absence of theelin, or that some synergistic action exists as between the two hormones. This latter alternative seems to be the more reasonable at this time although it is not conclusively demonstrated.

The action of theelin in two completely thyroidectomized birds (Nos. 6751 and 6748) is presumably independent of complementary thyroid effect. In both these birds theelin brought about plumage changes in the direction of, but by no means the equivalent of, modifications known to occur in normal males or capons following either theelin or thyroid administration. Although thyroid removal appears to have been complete in both birds, numerous repetitions of such an experiment are required before indicated conclusions can be accepted without reservations.

Reactions exhibited in breast tracts, particularly posterior areas, of athyroidic Brown Leghorn capon No. 8852 are striking evidence that theelin in sufficiently high concentrations does modify, in certain follicles, the processes of feather growth and differentiation. Further, pigmentation changes effected in posterior breast feathers are remarkably similar in certain respects to pigmentation changes usually associated directly with changing thyroid levels in Brown Leghorns. It is a reasonable inference that the black, or dark, spot appearing with initiation of injections was the result of relatively low theelin concentrations during a limited period. With increasing theelin concentrations in the blood stream, assuming only some cumulation of theelin content with continued daily injections, the same feathers became blanched and remained so during the term of injections. The next generation of feathers from identical follicles came in following cessation of theelin injections, and reappearance of black probably is again associated with lowered theelin concentrations. The greater extent of melanized areas in these latter feathers would be expected if a gradual but long continued absorption of theelin occurred following cessation of injections. The quantity of oil in the cyst found in this bird indicates such a condition, with maintenance of threshold requirements.

These reactions certainly have their parallel in typical reactions caused by thyroid administration to the normal Brown Leghorn; relatively low concentrations bring about extension of melanization, whereas relatively high concentrations lead to a more or less pronounced blanching or dilution of feather pigments.

If the results presented here are taken in their entirety, theelin appears to act, within limits, on feather follicles in a manner suggesting either complementary or parallel action with thyroid secretions. Confirmation of these observations, their extension to the thyroid-theelin relationship in the normal female fowl, and analysis of the mechanism underlying observed effects must await conclusion of experiments now in progress.

SUMMARY

The effects of theelin, subcutaneously administered, on the plumage of partially and completely thyroidectomized males and capons have been studied in connection with the relative levels of thyroid activity in male and female domestic fowl.

Preliminary results indicate that theelin in apparently completely thyroidectomized males and capons induces structural modifications similar in certain respects to those known to follow hyperthyroidism in the male or castrated fowl with intact thyroids. In one instance (athyroidic Brown Leghorn capon) color modifications resembling those obtained following thyroid administration to the normal male or capon have been observed.

In a thyroidectomized capon with residual thyroid less than one-sixteenth of the mass in capons with intact thyroids, both structural and color modifications following theelin administration are very similar to those induced in the normal or castrated male.

The tentative conclusion drawn from these experiments is that theelin and thyroid secretions complement in some manner not yet clear the action of each other in the feather follicle, and that it probably is not necessary to suppose a higher level of thyroid activity in the female than in the male in order to explain the female type of plumage.

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HORMONAL REGULATION OF MOLT AND OVULATION

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During 1937-38, a series of experiments was carried out on the Experimental Poultry Farm attached to the Calvé-Delft Oil Mills in Delft (Netherlands) on the effect of hyperthyroidization of White Leghorns (*1*).[1]

In the course of these experiments, 400 experimental birds and 100 control birds were used. All the birds were hatched in the spring and reared in the usual way, and the housing and treatment were on modern lines.

A preparation, consisting of dried, extracted, ground, pig-thyroid gland, was administered orally. This powder contained 0.2 percent of iodine and 12.7 percent of nitrogen. The doses administered varied from 2 to 20 grams per bird. Some of the results obtained from the experiments, in which the desired quantity was given in one dose, are summarized as follows.

APPEARANCE OF THE MOLT AFTER THYROID FEEDING

The birds undergo a molt, varying from slight to complete, 7 or 8 days after thyroid administration. The progress of this molt on the body, legs, and neck follows the natural procedure, although the molt on the wings and legs has little connection with that on the body. To determine the extent of the artificial molt and to express it as one figure, a scale of seven points (table 1) has been drawn up, based on the degree of molting on the body, legs, and neck.

TABLE 1.—*Progress of the molt on the body, neck, and legs*

Point No.	Back	Body (except the back) and caudal part of the neck	Oral part of the neck	Legs
1	Small bare patch	No molt	No molt	No molt.
2	Good-sized bare patch	Two narrow bare strips on both sides along neck and flanks.	do	Do.
3	Large bare patch	Two broad bare strips along neck and flanks.	do	Slight scattered molt.
4	Bare	Bare, except for two narrow strips of down on the boundary of back and flanks, and a fairly broad strip of down along the breastbone.	Slight molt on the ventral side only.	A half scattered molt.
5	do	Bare except for a narrow strip of down along the breastbone.	Definite molt on the ventral side, not on the dorsal side.	Definite scattered molt.
6	do	Bare	Bare except for the dorsal top feathers.	Bare.
7	do	do	do	Do.

On the basis of the relationship of the weight of the feathers from the different parts of the body, the molt of the wings was expressed in a scale of three points and the molt of the tail in a scale of two points.

For each bird, the final condition of the experimental molt, attained 14 to 25 days after hyperthyroidization, was estimated, and this final condition expressed as the sum of three figures, thus in one scale varying from 0 to 11.

[1] Italicized numerals in parentheses refer to Literature Cited, p. 112.

The extent of the molt, expressed in this scale, is not wholly in direct proportion to the dose administered, but a larger dose usually causes a more definite molt than a smaller dose. Further, it appears that the extent of the molt depends very largely on the time of year, when the experiment is taken. Four periods can be distinguished in this respect:

1. With pullets, the first period lasts from January until May, the dose required to give a "half molt" (average of 5.5 in the previously mentioned scale) gradually diminishing from 11 to 6 grams of the preparation, as shown in the following:

Date	Approximate dose required to give a half molt
	Grams
January 8	11
February 12	8
February 27	6.5
March 19	7.5
April 11	6.0

2. During the summer, the sensitivity is very strong, the dose required to give a half molt being 3 grams on July 7 and also on August 2.

3. As soon as the natural molt begins in the autumn, it is almost impossible to influence the feathering by feeding thyroid to the birds.

4. After the natural molt, the feathers of the second-year birds are very resistant to thyroid feeding, but there is a steady and fairly rapid increase in sensitivity. The fourth period merges into the first, and the cycle is completed in February or March. The doses required in the fourth period to give a half molt are as follows:

Date	Approximate dose required to give a half molt
	Grams
December 4	Much more than 15
January 8	14
February 12	9
March 19	6

The threshold, above which the hormone concentration must rise before the feather follicles are stimulated to growth, may be very different for the individual follicles and decreases according to the age of the feathers. But this phenomenon is not sufficient to explain all the results obtained in the experiments. It is probable that, in addition to variations in the sensitivity of the feather follicles to thyroid feeding, there are also fluctuations in the general sensitivity.

DIRECT EFFECT OF THYROID FEEDING ON EGG PRODUCTION

After the administration of the preparation in one dose to birds in full production, one to three eggs are usually laid, but the production is then temporarily interrupted. The duration of this interruption varies greatly with the individual and is, on an average, in direct proportion to the dose administered, although this statement applies only to a certain limit. By increasing the doses, the interruption eventually reaches a maximum which, within the bounds of the experiments, cannot be prolonged by feeding larger quantities. The sensitivity of the birds in this respect is also very different at varying seasons of the year, as shown in table 2.

TABLE 2.—*Effect of season of year on results of thyroid feeding*

Age of bird and season of year	Interruption of production per gram of thyroid preparation	Approximate maximum duration of interruption
	Days	*Days*
Pullet year:		
Jan. 8, 1938	3.08 ± 1.21	45
Feb. 12, 1938	3.40 ± 1.12	45
Feb. 27, 1937	2.43 ± 0.84	
Mar. 19, 1937	$2.13 \pm .48$	
Mar. 19, 1938	$3.04 \pm .72$	
Apr. 11, 1937	$3.46 \pm .10$	45
July 7, 1937	$4.11 \pm .35$	40
Aug. 2, 1937	9.88 ± 1.39	
Second year:		
Dec. 4, 1937	$1.88 \pm .17$	20
Jan. 8, 1938	$1.53 \pm .22$	20
Mar. 19, 1938	$3.48 \pm .82$	30

After the temporary interruption, normal egg production is resumed. The hyperthyroidization, as carried out in my experiments, did not appear to have either a favorable or an unfavorable effect on the laying capacity of the birds or on the weight of the eggs produced.

The interruption in production, after thyroid administration, is probably not caused by any specific reaction on the thyroid hormone but results from a disturbance in metabolism, due to feeding thyroid to the hens.

EFFECT OF HYPERTHYROIDIZATION ON THE MOLTING AND THE LAYING CYCLES

When a complete or partial molt is induced by thyroid feeding during February, April, July, August, or September, it is extremely rare that the birds molt again in the autumn, i.e., during the season of the natural molt. Despite the fact that the normal molting cycle of the birds is disturbed by hyperthyroidization, the laying cycle is apparently not affected.

Although the experimental birds do not molt again naturally, they do, however, cease production in the autumn, which event, with normal birds, occurs simultaneously with the molt.

A comparison of the trap-nest records of the experimental birds and the control birds shows that neither the beginning of this natural period of rest nor its duration is affected by the previous thyroid feeding. When the natural period of rest begins during the interruption in production owing to thyroid administration, the duration of the combined interruption is then reduced to a comparatively constant period, lasting on an average 66 to 86 days, and this appears to be quite independent of the duration of the natural interruption.

CONTROL OF THE ANNUAL CYCLE

The observation that the annual molting cycle is affected by thyroid feeding, whereas the laying cycle is not affected, renders the generally accepted assumption of unity of control of the molting and laying periodicity very problematical.

The two existing theories on the control of the annual cycle—those of Zawadowsky (*2*, *3*) and Greenwood (*4*)—assume that there is one mechanism by which the molting and laying periods are alternately stimulated.

From the results of my experiments and from observations on various nondomesticated birds, e.g., Kuhn (*5*) and Marshall (*6*), it seems probable that the molting and the laying cycles are two separate phenomena, which are controlled by two different mechanisms, although there is a secondary interaction between the two. The following hypothesis has been set up in connection with these two mechanisms.

Control of the molting cycle

We must accept the assumption that the annual molt is caused by increased thyroid activity of the birds, although it is desirable that this assumption should be supported by further experiments. The thyroid activity, in turn, depends on the function of the anterior lobe of the pituitary, which introduces the thyrotropic hormone into the blood stream. An injection of thyrotropic hormone also causes a molt, similar to that which follows thyroid feeding, according also to Walker (*7*). The rhythmic fluctuations in the excretion of the thyrotropic hormone, which control the molting cycle, are dependent on other factors, believed to be environmental, but whose exact nature is still not definitely determined. It seems probable, however, that variations in light or temperature, or both, are the most important, according also to Beebe (*8*).

Control of the laying cycle

Heape's hypothesis (*9*) that the sexual cycles of animals were due to changes in environmental circumstances such as climate or feeding, which created a "generative ferment" in the blood, has in later years received increasing support. It has been demonstrated with hens that the function of the ovary is controlled by the gonadotropic hormone of the anterior lobe of the pituitary.

It was learned, from practical experience, that artificial lighting improved egg production during the winter. From this fact, to which may be added further the data of Bissonnette, (*10*), Ceni (*11*) and Whetham (*12*), it would appear that fluctuation in the amount of light is one of the external circumstances which controls the secretion of the gonadotropic hormone and with it the laying cycle.

It is not yet known how far other factors may influence this mechanism which controls the laying cycle.

Relationship between the molting and the laying cycles

The conception, outlined above, regarding the two separate mechanisms which control both annual cycles will serve to explain that, although with some birds the molt is greatly delayed with respect to the minimum during gonad activity whereas with hens the molt and the annual resting period coincide, these are two entirely different phenomena. It also helps to explain the contradictory results obtained from experiments on the effect of a preparation of the anterior lobe of the pituitary on the egg production and the molt of hens. If such preparations are strongly gonadotropic, they will stimulate the ovarian function, but if they are preponderantly thyrotropic, they will have precisely the reverse effect and cause molting, according to Walker, (*7*), Gutowska (*13*), Asmundson (*14*), and Koch (*15*).

Further, the controversy on the effect of removing the pituitary of birds may also be explained in this way. Mitschell (*16*) observed that, after partial removal of the anterior lobe of the pituitary, the thyroid gland became very small and the molt of the birds so treated began later and made much slower progress than was the case with normal birds. Hill and Parkes (*17*, *18*) succeeded in keeping birds alive, after removal of the pituitary, by injecting an extract of the anterior lobe of the pituitary for 4 to 6 days. In these birds, however, a definite molt occurred about a week after the operation. Mitschell's results confirm the opinion that the molt is controlled by the thyrotropic factor and the thyroid hormone. Hill and Parkes' results may be explained as follows. Their experimental birds only remained alive if they were treated with an extract of the anterior lobe of the pituitary, which, from their experiments on guinea pigs, was strongly thyrotropic. Thus it may be presumed that the thyroid gland of the experimental birds, which later became nonactive, was nevertheless temporarily stimulated into strong activity, thereby causing molting. Moreover, from experiments with dogs, as carried on by Houssay (*19*), it has been ascertained that the thyroid gland is rather more active for a few days following the removal of the anterior lobe of the pituitary, probably owing to quantities of thyrotropic hormone being released into the blood stream during the actual operation.

Although the mechanisms controlling the molting cycle and the laying cycle are independent of each other, they may, in certain circumstances, affect each other. This was to be expected owing to the fact that the anterior lobe of the pituitary plays an important part in both functions. Aron and Benoit (*20, 21*) demonstrated that the gonad function may have a retarding influence on the excretion of the thyrotropic hormone from the anterior lobe of the pituitary. This phenomenon may serve to explain the observation that a sudden interruption in egg production may or may not cause molting. In practical poultry farming it is well known that various disturbing factors (such as sudden changes or disturbances in feeding or water supply, changes in housing, alteration in artificial lighting) not only affect egg production unfavorably, but may sometimes cause a slight or complete molt. If the ovarian function checks, to a certain extent, the secretion of the thyrotropic hormone, and if this check is suddenly removed by an interruption in egg production, then the possibility that a molt will occur is increased. Whether a molt does or does not occur depends in the first place not on the removal of the checking effect of the gonad function, but on the condition of the mechanism which controls the periodical molt.

In the summer, hens are sometimes intentionally treated in various ways in an attempt to force them to molt, and thus by getting the molting and resting period over earlier, to increase the egg production during the winter. It has, however, never been proved definitely that the desired result can be achieved in this way, and the possibility that the molting and the laying cycles are two entirely different factors makes it extremely doubtful whether this object can be achieved in this way. Further, it is remarkable that the artificially induced interruption in egg production is not necessarily accompanied by molting. This strange fact is, as already explained, understandable, if one grants that there are two mechanisms, one which controls the molting cycle and one the laying cycle, and also that the gonad activity is a check on the secretion of the thyrotropic hormone.

SUMMARY

A thorough investigation has been made on the influence of the thyroid hormone on the molting and the laying cycles of White Leghorns.

The results of this investigation seem to indicate that the molting and the laying cycles of hens are controlled by two different mechanisms. The following hypothesis on the nature of this control has been set up:

The periodical molt is brought about by fluctuations in the thyroid activity, which is, in its turn, dependent on variations in the secretion of the thyrotropic hormone of the anterior lobe of the pituitary. The activity of the pituitary in this respect depends on variations in external circumstances, among which are changes in light and temperature.

The periodicity of the ovarian function is controlled by variations in the gonadotropic-hormone secretion of the anterior lobe of the pituitary.

Although the two mechanisms are quite independent, they may affect each other in a secondary way, as the gonadic function can act as a check on the thyrotropic-hormone secretion of the anterior lobe of the pituitary.

The experiences and experimental results obtained on this subject to the present time can all be explained by this theory.

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RELATION OF BLOOD-LIPID LEVEL TO REPRODUCTION IN THE DOMESTIC FOWL

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The fact that the blood of laying chickens contains higher levels of lipids than are contained in the blood of males and immature females has been reported by several investigators. Warner (*1*)[1] and Warner and Edmond (*2*) found more blood fat in laying than in nonlaying birds, but found no correlation between blood fat and egg yield. A rise in fatty acids and lipid phosphorus in the laying bird was also reported by Lawrence and Riddle (*3*). These workers further stated that the plasma of the nonlaying female contained more fatty acids than the plasma of the male bird, but this finding was not confirmed in the more extensive work of Warner and Edmond. Greenberg, Larson, Pearson, and Burmester (*4*) confirmed the rise in fat and phospholipids during the laying period. Kaishio (*5*) found no difference between the cholesterol content of the blood of nonlaying female birds and male birds.

In an investigation made at this laboratory (*6*), the levels of the various blood-lipid constituents, namely, cholesterol (both free and esterified), neutral fat, and phospholipids, were studied in male and female Single-Comb White Leghorns of various ages. In order to determine the possible influence of dietary fat, two rations were used. These differed only in their fat and carbohydrate contents. One contained 18 percent, and the other, less than 1 percent, of fat, the remainder being replaced, isocalorically, by starch.

TABLE 1.—*Mean values and standard errors of whole-blood lipids of male and female birds*[1]

Summarized from Lorenz, Entenman, and Chaikoff (*6*)

Class of birds	Fat level of diet	Analyses	Cholesterol		Total fatty acids	Phospholipid
			Free	Ester		
		Number				
Males	Low	12	92 ± 4	22 ± 3	314 ± 13	299 ± 8
	High	12	88 ± 3	42 ± 6	331 ± 18	304 ± 10
Immature females	Low	7	83 ± 4	35 ± 6	329 ± 19	232 ± 11
	High	6	80 ± 4	39 ± 7	361 ± 33	288 ± 12
Laying birds	Low	36	109 ± 4	16 ± 3	1564 ± 146	642 ± 33
	High	32	108 ± 5	29 ± 4	1209 ± 110	572 ± 30

[1] Values were obtained in the postabsorptive state. The values are expressed in milligrams per 100 cc of whole blood.

The blood analyses of these birds are summarized in table 1. The blood-lipid levels of male birds did not change significantly within the period studied, that is, between the ages of 71 and 276 days, and essentially similar blood-lipid values were found in immature female birds 71 to 135 days of age. In the laying bird, however, marked increases were observed in the blood levels of free cholesterol, phospholipids, and neutral fat, but no increase was observed in the cholesterol ester level.

With the exception of cholesterol ester, the average blood-lipid levels were independent of the level of dietary fat, but this one fraction was increased as fat replaced carbohydrate in the diets of male and mature female birds. Reduction of the fat content of the diet increased the variability of blood neutral fat and free cholesterol of laying birds, however.

The observed increase in blood lipids occurs a short time previous to the time the first egg is laid. This observed close relation between blood lipids and ovarian activity suggested a study of the effects of artificial stimulation of the ovaries of immature birds (*7*). For this purpose, daily injections of a quantity of pregnant-mare serum containing 150 rat units of gonadotropic hormone were made in a series of pullets 59 to 77 days of age. The injection period varied from 8 to 27 days. Blood fatty-acid values are summarized in table 2. In this and subsequent experiments, although all blood-lipid constituents were measured, only total fatty acids are reported. In every case, where a change in fatty-acid level was found, similar though smaller changes were found in the free cholesterol and phospholipid levels.

TABLE 2.—*Effect of pregnant-mare-serum injections*[1] *on blood fatty-acid levels of immature female birds*[2]

Summarized from Entenman, Lorenz, and Chaikoff (*7*)

Duration of treatment (days)	Analyses	Weight of oviduct			Blood fatty acids in 100 cc of whole blood		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
	Number	*Grams*	*Grams*	*Grams*	*Milligrams*	*Milligrams*	*Milligrams*
0	14	0.16	0.06	0.25	256	198	300
8–11	4	9.00	[3]	9.74	429	385	494
19–23	9	10.50	6.70	14.19	753	398	1,530
27	5	17.82	13.54	26.92	1,336	598	2,220

[1] All birds received 150 rat units per day.

[2] Values were obtained in the postabsorptive state. Ages varied between 59 and 77 days at the time blood samples were taken.

[3] Oviducts obtained only from 11-day injected birds.

Table 2 shows that a marked increase in the level of this constituent followed pregnant-mare-serum injections, and this increase became greater the longer the injections were continued. Although considerable variability was observed

[1] Italicized numerals in parentheses refer to Literature Cited, p. 115.

between the responses of different birds, the increase was statistically highly significant when tested by analysis of variance.

At the time of autopsy, no ova were observed in the stage of rapid yolk deposition, and consequently no relation existed between the increased blood-lipid levels and withdrawal of fat from the blood by rapidly growing yolks. A close relation was observed, however, between blood-lipid levels and the size of the oviduct. Increased blood lipids occurred only in birds with oviducts greater than 10 grams in weight.

Since oviduct growth is controlled by the estrogenic hormones, it seemed likely that the blood-lipid level might be under the control of the same or a similar mechanism, and that increased production of estrin by the ovaries of the birds injected with pregnant-mare serum might be responsible both for the rapid oviduct growth and for the increased blood-lipid levels. Under such a mechanism, it would be expected that injections of estrin would be effective on males as well as females.

A series of experiments was undertaken to test this hypothesis (*8*). In the first experiment, several immature birds were given injections of varying quantities of a crude estrin concentrate. For one group of birds the total dose was divided into three equal parts and injected at 8 a.m., 12 m., and 4 p.m. of the same day, and blood was taken 24 hours after the first injection. For a second group the dose was divided into six parts, injected during 2 successive days and the blood taken 48 hours after the first injection. The results of the estrin injections are recorded in table 3. Definite blood-lipid increases were observed 24 hours after the first injection in birds that received 1,000 to 3,000 rat units of estrin, and with the same total dose the response was greater when injections were made during 48 hours than when they were made during 1 day. The magnitude of the response in males was not so great as it was in females, but it was none the less definite.

TABLE 3.—*Effect of estrin injections on blood fatty-acid levels of immature birds*[1]

Summarized from Lorenz, Chaikoff, and Entenman (*8*)

Sex	Total dose	Interval after first injection	Injections	Birds	Blood fatty acids in 100 cc of whole blood		
					Mean	Minimum	Maximum
	Rat units	*Hours*	*Number*	*Number*	*Milligrams*	*Milligrams*	*Milligrams*
Female	[2] 0	......	......	7	323	285	358
Male	[2] 0	......	......	6	312	245	361
Female	3,000	24	3	2	850	780	919
Do	2,000	24	3	2	828	640	1,015
Do	1,000	24	3	2	628	577	678
Do	500	24	3	2	540	471	608
Do	2,000	48	6	2	961	774	1,148
Male	2,000	24	3	3	561	529	600
Do	2,000	48	6	3	882	857	899
Female	3,000	3	1	4	334	302	366
Do	3,000	6	1	4	338	296	410
Do	3,000	12	1	4	561	477	607

[1] Values were obtained in the postabsorptive state. Ages varied between 66 and 74 days at time injections were begun.
[2] Control birds received corn-oil injections.

A second series of experiments was designed to determine how quickly the response to estrin could be observed. Single injections of 3,000 rat units were given to a series of birds, and blood was taken from different ones of these individuals 3, 6, and 12 hours later. Positive responses were obtained from the birds that were left for 12 hours but not from those that were sampled at 3 and 6 hours (table 3), indicating that estrin in the form used can act in less than 12 hours after absorption.

The rapid action of estrin on blood lipids offers a mechanism by which the increase of blood fat with maturity could be explained. The experiments described, however, do not prove that this mechanism is the normal one or the only one that operates in the bird's body. An attempt has been made to throw light on this problem by a study of normal birds in the stage of rapid comb growth before the first egg is laid.[2] Blood samples were taken from 30 such birds and immediately afterward the birds were killed and autopsied. These data are summarized in table 4. Here can be seen the close relation that the blood-lipid level bears to the weight of the oviduct. No increased levels occurred when the oviduct was less than 15 grams in weight (a figure that is closely comparable, on the basis of percentage of body weight, to the 10-gram maximum observed in birds injected with pregnant-mare serum), and yet all birds that had larger oviducts also had increased blood-lipid levels. Thus it appears evident that the same mechanism may be sufficient to account for at least a considerable portion of the blood-lipid control.

TABLE 4.—*Oviduct weight and blood fatty-acid levels of birds during normal puberty*[1]

Summarized from Chaikoff, Entenman, Lorenz[2]

Number of birds	Weight of oviduct			Blood fatty acids in 100 cc of whole blood		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
	Grams	*Grams*	*Grams*	*Milligrams*	*Milligrams*	*Milligrams*
8	2.88	0.77	4.56	310	184	411
6	6.68	5.21	8.80	314	181	397
3	16.16	15.36	17.24	654	532	813
8	23.91	20.55	29.84	2,116	698	3,385
4	33.04	30.30	37.38	2,351	1,368	5,112

[1] Values were obtained in the postabsorptive state.
[2] Manuscript in preparation.

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[2] CHAIKOFF, I. L., ENTENMAN, C. E., and LORENZ, F. W. [Manuscript in preparation].

Beyond this, however, the relation is not so definite. There was considerable variability of blood-lipid levels in addition to the variation that followed the oviduct size. This result is not surprising, however, when it is considered that the size of the oviduct at any given time is an integral result of the action of estrin over a period of several days, whereas, from the results of the estrin injections described here, it may be inferred that the blood-lipid level may fluctuate much more rapidly in response to any change in the estrin content of the system.

SUMMARY

The neutral fat, phospholipid, and free cholesterol contents of the blood of laying birds are appreciably greater and more variable than the levels of these substances in the blood of males and immature females.

Daily injections of 150 rat units of gonadotropic hormone contained in pregnant-mare serum for periods of 19 to 27 days significantly increased the blood-lipid levels of immature female birds.

Injections of estrin significantly increased the blood-lipid levels of immature male and female birds. The response was observed as early as 12 hours after the injection.

The increase in the blood-lipid level of normal pullets occurs a few days before the first egg is laid. The onset of the increase is closely related to the amount of development of the oviduct.

It is suggested that the blood-lipid level of birds is controlled, at least in part, by the estrin produced in the birds' ovaries under the action of the gonad-stimulating hormone.

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HEMATOLOGICAL CHANGE IN THE SETTING HEN

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INTRODUCTION

As the bird reproduces by hatching, broodiness is an important avian instinct from an ornithological standpoint. Especially in the domestic fowl, the laying capacity of the hen has a close relationship to the occurrence of broodiness. Therefore, the study of it is needed from a physiological as well as from an economical point of view. At present, the cause and the true nature of it are not well known, except for some knowledge of its inheritance, the hormonal effect on it, and metabolism during the sitting period. The first object in the study of broodiness is, therefore, to find the true nature of it, that is the constitutional changes in the sitting hen. In the present study, the authors compared the blood cells of the sitting hen with those of the laying hen.

MATERIAL AND METHODS

The birds used were eight sitting hens, namely, five Nagoyas, two Nagoya × White Leghorn crosses, and one Rhode Island Red. Nine laying hens, consisting of seven Nagoyas and two Nagoya × White Leghorn crosses, were used as controls. Blood taken from the wing vein by puncture, was stained by May's and May-Giemsa's staining fluids as a dry smear, and the total number of blood cells was obtained in Thoma's counting chamber. Owing to the existence of the spindle cell, which corresponds to the mammalian blood platelet, or thrombocyte, and of the nucleus in the erythrocyte, the number of erythrocytes and leucocytes cannot be determined by the usual chamber staining method. Therefore, the estimation was made from the number in the dry smear.

RESULTS

The results obtained, as well as data of other workers on nonsitting hens, are shown in table 1.

The total number of all blood cells was 23 percent less in the sitting hen than in the laying hen. The number of erythrocytes was 22 percent less in the former than the latter, the spindle cells 40 percent less, and all leucocytes 48 percent less. Though the absolute number of all leucocytes and the number of each leucocyte were lower in the sitting hen, the percentages of the various leucocytes were higher in most instances. The percentages of small and large lymphocytes were lower, but the other leucocytes were higher.

DISCUSSION

From the observations given, it may be said that the sitting hen is in an anemic condition. However, the number of hens examined and the number of examinations made were too small to determine the exact relationship between broodiness and the anemic condition. This condition may be brought about by irregular feeding, lack of nutrition, poor exercise, and lowered general physical condition as an effect of sitting. In fact, after hatching takes place, the mother bird often loses weight and her comb and the wattles become pale and small. The authors' opinion is that the cause of the anemic condition is probably as follows: The wasting and destruction of blood cells continue as normally, but the new formation and complement of them are greatly retarded by the subnormal physical condition of sitting. In order to find how and when this anemic condition occurs, further studies are needed.

TABLE 1.—*Number and average percentage of blood cells in 1 cubic millimeter of blood, in sitting and nonsitting hens*

Authors data

Condition of hen	Hens used	Examinations	Total blood cells	Erythrocytes	Spindle cells	Number and average proportions of indicated leucocytes						
						Total	Pseudo-eosinophilic	Eosinophilic	Mast	Small	Large	Megakaryocyte
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Sitting	8	9	2,122,667	2,078,872	24,778	19,017	35.0	5.3	5.8	39.7	10.0	3.8
Laying	9	11	2,755,909	2,678,328	41,236	36,345	20.7	2.0	1.5	60.4	12.4	3.0
Data of other investigators												
Nonsitting[1]	....	....	3,415,540	3,350,000	30,060	35,480	24.0	2.8	2.8	63.4	6.6	....
Do.[2]	....	....	2,935,714	2,870,835	35,936	28,943	28.9	1.1	2.8	43.3	13.6	10.4

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SUMMARY

Though broodiness is an important avian instinct from a physiological as well as from an economical standpoint, the cause of it is not yet well known. The authors compared the blood cells of sitting hens with those of laying hens. Eight sitting hens were examined, namely, five Nagoyas, two Nagoya × White Leghorn crosses, and one Rhode Island Red. Nine laying hens, consisting of seven Nagoyas and two Nagoya × White Leghorn crosses, were used as controls. Blood taken from the wing vein by puncture was stained by May's and May-Giemsa's stains. The results were as follows:

The total number of all blood corpuscles in 1 cubic millimeter of blood was 2,122,667 in the sitting hens as compared with 2,755,909 in laying hens, a difference of 23 percent.

In the same groups of birds the numbers of erythrocytes were 2,078,872 and 2,678,328, respectively, the difference being 22 percent.

The numbers of spindle cells, which correspond to mammalian blood platelets, or thrombocytes, were 24,778 and 41,236, respectively, the sitting hens having 40 percent less.

The sitting hens and laying hens had 19,017 and 36,345 leucocytes, respectively, the difference being 48 percent.

In percentages of the various leucocytes, the sitting hens were lower than the laying hens in small and large lymphocytes but high in pseudoeosinophilic, eosinophilic, mast, and megakaryocyte lymphocytes. It may be concluded from the observations made that the sitting hen is in an anemic condition.

INFLUENCE OF A SOJOURN IN THE MOUNTAINS ON THE BLOOD COMPOSITION, BODY DEVELOPMENT, AND EGG PRODUCTION OF WHITE LEGHORN PULLETS

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The Zootechnical Institute and Dairy Industry Unit for Piedmont has an Experimental Alpine Station in the high valley of Susa, on the pasture ground of Grand Chalp (Salice d'Ulzio), 6,000 feet above sea level. A series of researches was carried on there to study the influence of the Alpine sojourn on blood composition and body development of animals (cattle and poultry) taken to the mountains during the summer. This paper gives the results of 2 years of research with poultry.

In 1937 the first series of physiological researches was begun on 10 White Leghorn pullets 4 months old, similar in weight, and all from the same hatch at the Experimental Poultry Center of Turin, a part of the Zootechnical Institute and Dairy Industry Unit. These chickens were taken to the Alpine station toward the end of June and remained there for about 3 months in the open air.

Red corpuscles were counted and the hemoglobin content per 100 cc of blood was determined at three different times, i.e., first in the lowlands (Turin, 790 feet above sea level, in June 1937), then in the mountains (Alpine station, 6,000 feet above sea level, in September 1937) and, lastly, in the plains again (December 1937).

In 1938, to determine whether the variations noticed in the previous year in the blood composition of the pullets during their stay in the Alps would not occur as well in poultry kept in the plains, in consequence of individual, climatic, or seasonal factors, two groups of eight White Leghorn pullets, of the same age and weight, were formed. Of these, one was sent to the mountains (Alpine Experimental Station), where it remained for about 2 months, whereas the second was kept in the plains, in Turin, as a control group. The mountain group was kept in a large enclosure and fed approximately the same as the lowland group. In addition to the obtaining of a count of the red corpuscles and a determination of the hemoglobin, the white corpuscles were counted. When this paper was written, two determinations had been made, the first in Turin (July 1938) and the second at the Alpine Station (August 1938).

Counting of the red and the white corpuscles was done by means of Thoma's hemacytometer; the hemoglobin was determined with a Zeiss-Ikon hemometer. For this last test it was necessary to centrifugate the blood with a N/10 solution of chlorohydric acid, in order to separate the nuclei of the red corpuscles that would have prevented an exact color comparison of the hemolized blood with the sample disc of the hemometer.

Blood samples were taken with a special lancet from the wing vein, in the morning, and all the analyses were made twice.

Data from the first set of tests (1937) for the three periods are as follows: The number of red corpuscles per cubic millimeter of blood—in the plains, 2,850,000; in the mountains, 3,370,000; and in the plains, 3,320,000. The hemoglobin in 100 cc of blood—in the plains, 5.68 g; in the mountains, 9.45 g; and in the plains, 8.28 g.

A comparison of the measurements shows that the Alpine season caused, in the pullets' blood, an increase of 520,000 red corpuscles per cubic millimeter of blood and of 3.77 of hemoglobin per 100 cc of blood. Much of this increase was still retained 2 months after the return to the lowlands (470,000 of the red corpuscles and 2.60 g of hemoglobin).

In the 1938 test with two groups of pullets, one was kept on the plains and the other sent to the mountains toward the end of July.

Table 1.—*Average data of the blood tests of the two groups (1938 test)*

Group classification	Red corpuscles per cubic millimeter of blood		Hemoglobin in 100 cc of blood		White corpuscles per cubic millimeter of blood	
	First count	Second count	First determination	Second determination	First count	Second count
	Number	*Number*	*Grams*	*Grams*	*Number*	*Number*
Mountain	3,050,000	3,670,000	5.05	8.30	23,200	6,500
Lowland	3,009,000	2,990,000	5.60	7.40	16,700	7,300

A comparison of the results of the two groups (table 1) shows that the pullets sent to the mountains had an increase of 620,000 red corpuscles and of 3.25 g of hemoglobin, and a decrease of 16,700 white corpuscles. For the lowland group, the second test (beginning of September) showed, in comparison with the first (July), a decrease of 19,000 red corpuscles, an increase of 1.8 g of hemoglobin, and a decrease of 9,400 white corpuscles.

Body-development and egg-production control were made in 1937 on two groups of 22 pullets each, the birds being 4 months old and of approximately equal average weight (918 g for the mountain group and 919 g for the lowland group.)

The experimental group, comprising the 10 pullets studied for blood composition, remained in the mountains about 3 months. During that time the poultry were fed a ration without meat or fish meal, because they could find and actually ate large numbers of grasshoppers (*Stauroderus scalaris*, Fisch. *Sternobothrus morio*, Az.).

The control group had in its ration 9 percent of meat meal and 5 percent of fish meal. After the Alpine period both groups were fed the same ration.

A monthly control of the pullets' weights showed that in the 3 months in the mountains the average weight of the group in the experiment was lower than that of the control group, being 1,543 g for the mountain group and 1,590 for the lowland group on October 1, 1937. However, in the months following the return from the Alps, the average weight was greater. On December 1, 1937, the average weight of the mountain group was 1,736 g, and of the control group, 1,654 g.

The beginning of egg laying was much more regular for the pullets that returned from the mountains, as most of them began to lay in October, whereas those of the other group began during a period between August and February.

The average egg production appeared to be higher for the mountain group at the sixth, eighth, and twelfth laying months, and the eggs heavier by a control by decades taken both at eighth, and twelfth laying months. Of the mountain group, the average production was 171.28 eggs and the average egg weight 54.88 g; of the lowland group, the average production was 154.3 eggs and the average egg weight, 53.94 g.

Percentage of losses was higher for the group that remained in the lowlands.

In 1938, tests were taken for body weight and egg production on two groups of 25 pullets each, about 4 months old and of approximately the same average weight (887.2 g for the mountain group; and 886.8 g for the lowland group).

The group under experiment stayed in the mountains about 2 months and was kept in a large enclosure. During that time it was fed the same ration as the lowland group, including 10 percent of meat and fish meals in equal parts.

From a monthly check of the birds after 2 months of sojourn in the Alps, the average weight of the pullets of the mountain group (1,642 g) was higher than that of the pullets of the lowland group (1,505 g) and remained higher also in the following months (average weight on January 12, 1938 for the mountain group was 1,780 g; for the lowland group, 1,728 g).

In 1938 also, the beginning of egg laying appeared to be more regular among the pullets returned from the mountains; two pullets in each group had not yet begun laying on January 1, 1939.

When this paper was written, results of the average egg production and average egg weight could not be given, owing to the short time since the beginning of laying.

SUMMARY

To study the influence of a sojourn in the mountains on the blood composition, body development, and subsequent egg production of young poultry, in 1937 a first series of researches was begun on a group of White Leghorn pullets. They were from the same hatch at the Poultry Center of Turin and were of similar weight. For about 3 months they were kept at the Experimental Alpine Station of the Zootechnical Institute and Dairy Industry Unit for Piedmont, in the high valley of Susa (Salice d'Ulzio), 6,000 feet above sea level.

To study the variations of the blood composition, the red corpuscles of 10 pullets were counted and the hemoglobin content was determined in three distinct periods, that is, in the lowlands (Turin, 790 feet above sea level, in June 1937), in the mountains (September 1937) and in the lowlands again 2 months after the return from the mountains (December 1937). In 1938 two groups of 8 White Leghorn pullets each were formed. One of these remained in the plains, and the other was kept in the mountains for about 2 months. Besides the same tests as those of the preceding year, the white corpuscles also were counted. When this paper was written, two determinations had been made: one in the lowlands (Turin, July 1938) and the other in the mountains (Alpine station, August 1938).

The tests showed the following results:

1.—The sojourn in the mountains caused, in the pullets' blood, an increase of red corpuscles (approximately 500,000 to 600,000 per cubic millimeter), an increase of the hemoglobin (3.25 to 3.77 g per 100 cc), and a decrease of white corpuscles (16,700 per cubic millimeter).

2.—These variations, though less evident, remained for 2 months after the descent to the plains.

3.—In the pullets that remained in the plains, probably because of individual or climatic and seasonal factors, there was a decrease in white corpuscles (9,400 per cubic millimeter), an increase, though slight, of hemoglobin (1.8 g per 100 cc of blood), whereas the number of red corpuscles remained almost unchanged.

4.—There is no exact correlation between the increase of the red corpuscles and that of the hemoglobin, because the increase of the latter is generally of a much higher proportional value than that of the former.

5.—The improvement in the blood composition of the pullets sent to the mountains seems to have a beneficial effect also on the general conditions of their organism.

The pullets used in the tests for weight increase and subsequent egg production consisted, in 1937, of 22 birds each, of approximately equal weight and about 4 months old. The experimental group stayed in the mountains about 3 months. During that time the pullets were fed a ration without meat or fish meals, as they ate a great many grasshoppers.

During the 3 months in the mountains, the average weight of the experimental group was lower than that of the control group, whereas in

the months following the birds' return, their weight was greater.

The beginning of egg laying was much more regular for the pullets that had returned from the mountains.

The percentage of losses was higher in the group that remained in the lowlands.

The average egg production was greater from the mountain group at the sixth, eighth, and twelfth egg-laying months, eggs being heavier by a decade control to the twelfth egg-laying month.

In 1938 the experiment was made with two groups of 25 pullets each about 4 months old and of approximately equal average weight. The experimental group stayed in the mountains about 2 months and was kept in a large enclosure. During that time it was fed on the same ration as the group kept in the lowlands. Both after the 2 months in the mountains and in the succeeding months, the average weight of the pullets of the mountain group was greater than that of the lowland group.

In 1938 also, the beginning of egg laying appeared to be more regular among the birds that returned from the mountains.

HÄMATOLOGISCHE STUDIEN AN DEN POLNISCHEN ZIELONONÓŻKI-HÜHNERN (GRÜNFÜSZLER)

Von Doc. Dr. Inz. Władysław Herman, *Dublany bei Lwów, Polen*

In dieser Arbeit versuchte ich auf dem Wege und unter Anwendung hämatologischer Arbeitsmethoden, das Vorkommen von Rassenmerkmalen im normalen Blute der polnischen Zielononóżki-Hühner festzustellen, die ich anderen Geflügelarten und anderen Hühnerrassen gegenüberstellte.

Nach meinen Untersuchungen scheint die Erythrozytenzahl und der Hb-Gehalt im Blute der Zielononóżki im Durchschnitt niedriger zu sein als es nach den Angaben der Fachliteratur im Blute anderer Hühnerrassen in der Regel zu sein pflegt. Dasselbe stellte ich auch in Bezug auf die Leukozytenzahl in 1 mm³ des Blutes fest.

Tabelle I.—*Allgemeine durchschnittliche Zusammensetzung des weissen Blutbildes. Zahl untersuchter Hennen 142*

	Prozent
Kleine Lymphozyten	59,5
Pseudoeosinophile Körperchen	21,0
Grosse Lymphozyten	11,7
Eosinophile Körperchen	5,7
Basophile Körperchen	1,1
Monozyten	1,0
	100,0

Die Zusammensetzung des weissen Blutbildes dagegen wich nur wenig von den bei anderen Hühnern gefundenen Zahlen ab. Näheres darüber ist aus der beigegebenen Tabelle leicht ersichtlich.

Im Blute der von mir untersuchten Zielononóżki kommen auch gruppenspezifische Strukturen vor, die auf dem Wege der Isoagglutination feststellbar sind. Nach den Ergebnissen meiner Studien muss im Hühnerblute das Vorkommen wenigstens drei verschiedener Agglutinine und drei ihnen entsprechender Agglutinogene angenommen werden, die ihrerseits wieder von verschiedener Wirkungskraft resp. verschiedener Empfindlichkeit sein können. Im allgemeinen aber ist das Vorkommen gruppenspezifischer Differenzierung im Hühnerblute verhältnismässig selten; auch kommen Tiere mit nur einer ausgebildeter Eigenschaft: Agglutinin oder Agglutinogen (sog. Defektgruppen) seh oft vor. Regelmässig dagegen bildet sich im Hühnerserum das anti-Menschenerythrozyten Heteroagglutinin aus, das in vielen Fällen auch eine gruppenspezifische Wirkung entwickeln kann. Am häufigsten beobachtete ich anti-B Wirkungen dieses Hetero-

Tabelle II.—*Erythrozytensenkungsgeschwindigkeiten in mm pro Stunde*

Versuchsstunde	Stundenmittelwerte		
	Hähne (16)	Kapaune (15)	Hennen (21)
1	1,89	3,06	2,38
2	2,19	3,86	2,27
3	2,43	4,03	2,76
4	2,37	4,33	2,90
5	2,37	4,36	3,07
6	2,62	4,78	3,01
7	2,60	4,46	3,25
8	2,73	4,28	3,40
9	2,67	4,50	3,15

agglutinins. Die Ballung der A-Erythrozyte war dagegen immer schwächer und äusserte sich erst nach längerer Zeitspanne der Versuchsdauer. Unter Anwendung absorbierter Sera konnte ich im Blute der Zielononóżki auch ein gruppenspezifisch wirkendes anti-O Heteroagglutinin feststellen. Im allgemeinen waren in meinem Versuchsmaterial gruppenspezifische anti-B, anti-B, O, anti-O und neben diesen, wenn auch schwächeres und langsamer wirkendes anti-A Heteroagglutinin zu finden. Es soll noch hervorgehoben werden dass nicht alle menschliche O-Erythrozyten sich in gleicher Weise den Hühnerblut anti-O Heteroagglutininen gegenüber verhalten. Wir konnten vielmehr unter ihnen mehrere, verschieden empfindliche Typen beobachten. Dem regelmässigen Auftreten eines anti-Menschenerythrozyten Heteroagglutinins im Hühnerserum gegenüber konnten wir in nur annähernd 3 Prozent aller von uns untersuchter Menschenblutproben ein Hühnerblutkörperchen ballendes Heteroagglutinin finden. Unter diesen zeigten sich aber die anti-A Agglutinine die wirksamsten.

Die Senkungsgeschwindigkeit der Erythrozyten muss als ein wichtiges biologisches Merkmal betrachtet werden, das in der medizinischen Diagnostik schon seit langem hoch geschätzt ist. Da Untersuchungen auf diesem Gebiete in der Tierzucht erst neueren Datums sind, verdienen alle weiteren, sogar kleinen Beiträge zur Kenntnis der Frage der Erythrozytensenkungsgeschwindigkeit bei den Haustieren beachtet zu werden. In meinen Arbeiten, in den ich unter Anwendung bekannter Methoden von Biernacki, Hirszfeld und Linzenmeier das Blut von Hähnen, Kapaunen und legenden Hennen untersuchte, zeigte es sich, dass diese Untersuchungsmethode uns das Durchführen einer Trennungslinie zwischen diesen drei Tiergruppen gestattet, die besonders scharf Kapaunen, von geschlechtlich vollwertigen Tieren trennt. Die oben angedeuteten Unterschiede treten besonders klar aus den in beigegebener Tabelle angeführten Ziffern zutage.

Da physikalische Bluteigenschaften eine grosse Rolle in der Entwicklung obenbeschriebener Phänomene spielen können, habe ich auch manche Angaben über Aschegehalt, Trockensubstanzmenge und spezifisches Gewicht des Blutserums unserer Zielononóżki zusammengestellt, die, wenn auch spärlich, doch aber unsere Kenntnisse auf diesem Gebiete bereichern werden.

Es soll noch hervorgehoben werden, dass ich in meinen Arbeiten über ein Versuchsmaterial von 289 Hennen verfügte, die alle einer Untersuchung in Bezug auf gruppenspezifische Differenzierung des tierischen Körpers unterzogen wurden. In anderen Versuchen gebrauchte ich andere Tierzahlen, wie ich es in den beigegebenen Tabellen veranschaulicht habe.

Biologisch-statistische Charakteristik morphologischer Zielononóżki-Bluteigenschaften:

1. Erythrozytenzahl pro 1 mm³ Blut:
   M 2 817 517,7 maximum 3 700 000,0
   minimum 1 920 000,0
   Amplitude 1 780 000,0
   Modalwert 2 720 000,0
   m 0,023089 v 9,7305 m_v 0,5794
   σ 0,27416 m_σ 0,0163268
2. Hämoglobingehalt in ° nach Sahli:
   M 53,35 max 68,5 min 39,5 Ampl 29,0
   Mod 55,0
   m 0,458 v 0,234 m_v 0,6072 σ 5,46
   m_σ 0,32399
3. Färbungsindex in Tausend Erythrozyten pro 1° Sahli:
   M 53,1267 max 74,7474 min 41,8750
   Ampl 32,8724 Mod 49,0
   m 0,5505 v 12,3478 m_v 0,7332 σ 6,56
   m_σ 0,38927
4. Hämoglobinindex in ° Sahli pro 1 Million Erythrozyten:
   M 19,05 max 23,88 min 13,38
   Ampl 10,50 Mod 19,00
   m 0,18076 v 11,307 m_v 0,6709 σ 2,154
   m_σ 0,1278
5. Oxyhämoglobingehalt in g pro 100 cm³ Blut:
   M 9,229 max 11,850 min 7,352
   Ampl 4,498
6. Leukozytenzahl pro 1 mm³ Blut:
   M 16,272 max 33,500 min 8,000
   Ampl 25,500 Mod 14,500
   m 0,38145 v 28,0287 m_v 1,1802 σ 4,22
   m_σ 0,24867
   Prozentzahl pseudoeosinophiler Körperchen:
   M 21,0697 max 35,00 min 10,000
   Ampl 25,000 Mod 24,500
   m 0,35166 v 20,0287 m_v 1,1802 σ 4,22
   m_v 0,24867
8. Prozentzahl eosinophiler Körperchen:
   M 5,7013 max 8 min 4 Ampl 4
   Mod 6
   m 0,0792 v 16,6748 m_v 0,9825
   σ 0,9507 m_σ 0,05602
9. Prozentzahl basophiler Körperchen:
   M 1,1944 max 3 min 0 Ampl 3
   Mod 1
   m 0,0395 v 39,7822 m_v 2,3377
   σ 0,475 m_σ 0,02799
10. Prozentzahl kleiner Lymphozyten:
    M 59,4861 max 74 min 45 Ampl 29
    Mod 55
    m 0,48683 v 9,8217 m_v 0,5785
    σ 5,842 m_σ 0,3442
11. Prozentzahl grosser Lymphozyten:
    M 11,7361 max 21 min 6 Ampl 15
    Mod 12
    m 0,24075 v 24,6163 m_v 1,4505
    σ 2,889 m_σ 0,1702
12. Monozytenprozentzahl:
    M 1,0277 max 2 min 0 Ampl 2
    Mod 1
    m 0,0168 v 19,675 m_v 1,1591 σ 0,2022
    m_σ 0,0119
13. Erythrozytenzahl pro 1 Leukozyt:
    M 184,474 max 250 min 80 Ampl 170
    Mod 185
    m 3,3664 v 21,0447 m_v 1,939 σ 38,822
    m_σ 2,3866

Physikalische Eigenschaften des Grünfüsslerblutes (Zielononóżki); Zahl untersuchter Hennen 54 untersuchter Hähne 11.

1. Trockensubstanzgehalt:
   Hennen M 17,52 Prozent max 20,12
   min 14,77 Ampl 5,35
   m 0,148 v 6,2413 σ 1,093 m_σ 0,105
   Hähne M 20,03 Prozent max 20,87
   min 18,87
2. Aschegehalt:
   Hennen M 1,024 Prozent max 1,110
   min 0,897 Ampl 0,113
   m 0,006 v 4,552 σ 0,046 m_σ 0,045
   Hähne M 1,083 Prozent max 1,218
   min 0,982 Ampl 0,336
3. Spezifisches Gewicht:
   Hennen M 1,018 max 1,028 min 1,011
   Ampl 0,017
   m 0,001 v 0,377 σ 0,003 m_σ 0,0007

SUMMARY

The red-cell count, leucocyte count, and the hemoglobin content of the blood of the Zielononozki fowls are lower than the average values given in the literature for other breeds of fowl. The relative numbers of the different kinds of white cells are similar to those reported for other breeds.

Isoagglutination studies indicated the presence of at least three different agglutinins and the corresponding agglutinogens. Many birds had only one developed agglutinin or agglutinogen (so-called defect groups). Anti-human-erythrocyte heteroagglutinin formed regularly in the blood of these fowl.

SECTION 2. NUTRITION AND INCUBATION

PROGRESS IN POULTRY NUTRITION

By R. M. BETHKE, *Associate (Nutrition), Ohio Agricultural Experiment Station, Wooster, Ohio, U. S. A.*

Poultry nutrition has become a science during the last two decades. The discovery in 1922 that rickets in chicks could be prevented by vitamin D and that cod-liver oil could supply this factor gave a great impetus to poultry-nutrition re-research. This discovery made the poultry industry independent of inclement weather. It made it possible to rear chicks indoors, regardless of season, and to keep laying hens confined the year round.

The confinement of the chicken indoors, however, has given rise to new problems which were not prevalent when by ranging at will the chicken was able to supplement her ration with insects, worms, and succulent green forage. Concurrent with these changes in management, changes in the manufacturing, processing, and milling methods of poultry feedstuffs have occurred, which have also added certain nutritional problems. These challenges have in part been met through the enlargement of the personnel and facilities for nutritional research the world over. As a result, the science of poultry nutrition had advanced to the point where its fund of knowledge is now the equal of any other branch of nutrition.

Although many investigators in the field of poultry nutrition have conducted their research work in a fundamental manner, they have not neglected the practical aspects of the problem under investigation. As a result, there has developed in poultry nutrition a mode of conducting nutritional research which is broader in its scope and of more important practical value than that of the other branches of animal nutrition. This mode of conducting research includes not only the discovery of nutritive essentials for the domestic fowl but also the application of these findings to the development of better rations. This involves the determination of the quantitative requirement for any nutritive essential for growth, egg production, hatchability, and maintenance of health; also the amount present in poultry feedstuffs, the variations in the amount present, and conditions which affect the quality and stability of the nutritive essentials during the preparation, either on the farm or in the manufacturing plant and in subsequent storage.

By adhering to this point of view, poultry nutritionists have worked out in a large measure the quantitative requirements of chickens, turkeys, and some game birds for proteins, the mineral elements calcium, phosphorus, and manganese, and for vitamins A, B_1, D, G (riboflavin), and the antidermatosis (filtrate factor) vitamin. Other work has shown that poultry require vitamins B_4, E, K, the antiencephalomalacia factor, the antigizzard erosion factor, and a new growth and reproductive factor. However, only meager information on the quantitative requirements of these factors is available.

Aside from the nutritive requirements for growth, production, and reproduction, a great deal of information has been obtained concerning the effect of the ration of the hen on the nutritive properties of the egg she produces. Some progress has also been made in the formulation of synthetic rations for chicks which will facilitate the further study of the different nutritive essentials as well as their quantitative requirements.

It is also of interest that poultry-nutrition investigations have made significant fundamental contributions to the study of the different kinds and forms of vitamins. Although some of these findings were originally considered to be of only fundamental nutritional or physiological interest without any direct application to poultry husbandry, they have, however, found some fundamental application in human nutrition and physiology.

In spite of the progress that has been made in poultry-nutrition research in the last two decades, many of the pertinent nutritional problems are still unsolved and should serve as a challenge to investigators in this field the world over.

The nutritional papers presented at this Congress are a good cross section of the magnitude of the research in this field and lend support to the fact that much progress has been and is being made in the fundamental and practical studies of this branch of science.

VITAMIN A REQUIREMENTS OF POULTRY

By ROSS M. SHERWOOD, *Chief of Division of Poultry Husbandry, Agricultural Experiment Station, College Station, Texas, U. S. A.*

In preparing this review of the studies of various research workers on the vitamin A requirements of poultry, some piece of work may have been overlooked, and if this has happened it is to be regretted. In the work reviewed, different units of vitamin A are used by different workers. In order to make the work comparable, the reviewer has interpolated all these units into International units. There may be some difference of opinion concerning the advisability of such interpolation and the values used. One International unit of vitamin A is estimated to be equivalent to 0.7 A. D. M. A. unit, 0.7 Sherman Munsell unit, 0.6 gamma of Beta carotene, 0.6 microgram of Beta carotene, and 1.0 U. S. P. 1934 unit.

SYMPTOMS OF VITAMIN A DEFICIENCY

Cruickshank (*5*)[1] points out that the symptoms of vitamin A deficiency do not usually appear in chicks before the third or fourth week. Growth is fairly normal up to this time; then it slows up and symptoms such as drowsiness, staggering gait, and incoordination of movement, accompanied by weakness, emaciation, and ruffled condition of the plumage, are noted. Some chickens develop xerophthalmia. These conditions continue for a short time, but death results in most cases before the end of the fifth week.

Post-mortem examination reveals pustulelike lesions in the mouth, pharynx, and esophagus, also accumulations of urates in the kidneys and renal tubules and sometimes on the surface of the heart, liver, and spleen. Urates often fill and distend the ureters.

Other conditions of the respiratory and alimentary tracts and eyes of chickens resemble those found in rats suffering from vitamin A deficiency. Secondary infections are often found since the lesions caused by the deficiency allow bacteria to enter.

In the absence of vitamin A, degenerative but not inflammatory changes are noted in both the central and the peripheral nervous systems. These are presumably responsible for the incoordination of movements which occurs in advanced stages.

Hinshaw and Lloyd (*9*), in describing the symptoms of vitamin A deficiency in turkeys, pointed out that the first symptoms are listlessness and unsteady gait; the birds tend to sit with sagging wings, drowsy heads, and closed eyes. Other symptoms are increased lachrymation, suggested by foaming of the lachrymal secretions, swelling of the nictitating membranes, and a slight nasal discharge. A milky exudate is usually a later symptom followed by the eyes being "glued" shut in the mornings.

VITAMIN A REQUIREMENTS FOR CHICKS

Ringrose and Norris (*14*), in a study of the vitamin A requirements of Leghorn chicks to 8 weeks of age, concluded that the minimum vitamin A requirement to this age was 150 U. S. P. 1934 units (150 International units) per 100 grams of feed. This amount prevented all symptoms of vitamin A deficiency.

Schroeder and coworkers (*16*) reported that it required 6,000 International units of vitamin A per pound of feed, equivalent to 1,322 International units per 100 grams of feed, to prevent clinical and pathological symptoms in growing chicks. They reported that fair growth resulted from 1,200 International units per pound of feed (264 International units per 100 grams of feed), but that there was a tendency for body weights to increase with increasing amounts of vitamin A in the feed.

Wilson and coworkers (*19*) reported that 1,200 International units of vitamin A per 100 pounds of feed (264 International units per 100 grams of feed) appeared to be adequate to promote satisfactory growth.

Record and his associates (*12*) found, in their prophylactic type of feeding, that it required a minimum of 50 to 100 micrograms of carotene (83 to 167 International units of vitamin A) or 80 to 160 International units of vitamin A from cod-liver oil per 100 grams of the ration to produce normal growth and prevent symptoms of deficiency in chicks up to 8 weeks of age. In their curative experiments, they found that it required 100 micrograms of carotene (167 International units of vitamin A) or 120 to 200 International units of vitamin A from cod-liver oil fed every other day to restore growth and prevent and cure symptoms of vitamin A deficiency in chicks that had been depleted of their vitamin A reserve up to 10 to 12 weeks of age.

Bearse and coworkers (*1*) report a study of the vitamin A requirements of pullets up to 24 weeks of age. They studied growth and vitamin A storage in the liver, as well as mortality, and estimated that it requires 175 Sherman Munsell units of vitamin A (250 International units) per 100 grams of ration.

Frohring and Wyeno (*7*), in studies with White Leghorn chicks fed to 8 weeks of age, state that minimum requirements were 65 A. D. M. A. units (93 International units) of vitamin A per day. These workers are of the opinion that the optimum requirements are much higher than this.

Hinshaw and Lloyd (*9*) reported that it required 4 grams of alfalfa meal containing 130 gamma of

[1] Italicized numerals in parentheses refer to Literature Cited, p. 125.

carotene per gram (217 International units) or a total of 520 gamma of carotene (867 International units of vitamin A) per 100 grams of feed to produce normal growth, low mortality, and no evidence of A-avitaminosis.

Kline and his associates (*10*) found that, when chicks are 7 to 8 weeks old, 0.03 milligram of carotene (50 International units of vitamin A) fed daily is not sufficient as the sole source of this vitamin and that chicks which have been depleted of vitamin A require more than 0.05 milligram of carotene (83 International units of vitamin A) daily to grow to maturity.

Biely and Chambers (*4*) found that the daily administration of 75 International units of vitamin A to chicks was sufficient to insure normal growth of chicks to 8 weeks of age.

Sherwood and Fraps (*17*) found that it required from 100 to 150 Sherman Munsell units (143 to 214 International units) of vitamin A per 100 grams of feed to produce good growth and cause low mortality with chicks hatched from eggs produced by hens receiving adequate supplies of vitamin A. With chicks hatched from eggs produced by hens fed a low vitamin A feed, the mortality was high during the first few weeks regardless of the amount of vitamin A in the feed. The vitamin A requirements for these chicks was 300 Sherman Munsell units (429 International units) of vitamin A per 100 grams of feed. Later unpublished data by Sherwood and Fraps indicate that 100 micrograms of carotene (167 International units of vitamin A) per 100 grams of feed causes normal growth with low mortality in chicks hatched from eggs of high vitamin A potency.

Summarizing the work on vitamin A requirements of growing chicks, the reports indicate that chicks hatched from eggs laid by hens on adequate diets will grow normally with very low mortality when fed from 125 to 175 International units of vitamin A per 100 grams of feed. Those hatched from eggs laid by hens on low vitamin A diets require much more vitamin A in the feed. In fact, the mortality from such chicks is high during the first few weeks regardless of the amount of vitamin A in the feed.

VITAMIN A REQUIREMENTS OF LAYING HENS

Bethke and associates (*3*) report that the fat-soluble-vitamin content of hen's egg yolk is greatly influenced by the amount of these substances in the ration and the environment of the hen. Yolks of eggs from hens on bluegrass range contain five times as much vitamin A as those not on bluegrass. The feeding of 2 percent of cod-liver oil in the ration had the same effect as the bluegrass range.

Koenig and coworkers (*11*) showed that the eggs from hens producing 230 eggs per year contained only 20 Sherman Munsell units (29 International units) of vitamin A per gram of yolk as compared with 33 Sherman Munsell units (47 International units) of vitamin A in the yolks of eggs from hens laying only 93 eggs per year; both received the same feed. This finding indicates that the requirements for hens producing large numbers of eggs are higher than for hens producing only a few eggs.

De Vaney and associates (*6*) present data showing the effect of vitamin A intake on the vitamin content of the egg yolks. The hens receiving the basal ration laid eggs containing 20 Sherman Munsell units (29 International units) of vitamin A per gram of yolk as compared with about 40 Sherman Munsell units (67 International units) of vitamin A per gram of yolk from hens receiving 1 and 2 percent of cod-liver oil and 80 Sherman Munsell units (114 International units) of vitamin A per gram of yolk from hens receiving 8 percent of cod-liver oil in their ration.

Record and his associates (*13*) report the results of two trials with White Leghorn pullets and estimate that the vitamin A requirements for good egg production and hatchability are from 350 to 400 U. S. P. 1934 units (350 to 400 International units) of vitamin A per 100 grams of feed. In another experiment these workers found that a minimum of approximately 400 micrograms of carotene from alfalfa leaf meal (667 International units of vitamin A) per 100 grams of feed was required for good egg production and hatchability.

Russell and associates (*15*) found that 2,200 International units of vitamin A per pound of feed (about 485 units per 100 grams of feed) gave as satisfactory results for egg production as did larger amounts of vitamin A.

Sherwood and Fraps (*18*) estimated that about 300 Sherman Munsell units (429 International units) of vitamin A for 100 grams of feed is required to maintain hens in good health and high egg production. This amount does not provide eggs of highest vitamin A content. Sherwood and Fraps (*18*) found that the vitamin A content of egg yolks increased with increasing amount of vitamin A in the ration. They estimated that it required 750 Sherman Munsell units (1,071 International units) of vitamin A for 100 grams of feed to allow the hens to produce eggs the yolks of which would contain a satisfactory amount of vitamin A.

Bearse and associates (*2*) reported that 500 Sherman Munsell units (714 International units) of vitamin A per 100 grams of feed in a breeding ration supplied sufficient vitamin A for maximum hatchability.

Titus[2] stated that he and his associates found it necessary to feed high-producing hens 1,000 to 1,100 International units of vitamin A per 100 grams of feed in order to produce eggs of a high vitamin A content. He stated that from their experience and from other observations they have tentatively suggested the following practical standards for the vitamin A content of poultry feeds: For growing chicks, 320 International units per 100 grams of feed; for laying hens, 700 Inter-

[2] Special correspondence.

national units of vitamin A per 100 grams of feed: for breeding stock, 1,040 International units of vitamin A per 100 grams of feed. He also stated that the minimum requirements of vitamin A were undoubtedly very much less than these amounts suggested as practical for feeding.

SUMMARY OF VITAMIN A REQUIREMENTS FOR HENS

From the work reviewed in this paper, it appears that for egg production when the vitamin A content of the egg is not considered, the hens should receive from 450 to 600 International units of vitamin A per 100 grams of feed. However, for breeding hens—high hatchability being a factor—or for special market eggs—a high vitamin A content of the eggs being desired—probably 1,000 International units of vitamin A per 100 grams of feed should be supplied.

VITAMIN A REQUIREMENTS FOR TURKEYS

Guilbert and Hinshaw (*8*) studied the effect of feed on storage of vitamin A in the livers of chickens and turkeys and found that on the same feed there was a greater storage of vitamin A in the liver of chickens than in turkeys. A direct correlation was noted between the vitamin A storage in the livers and the amount of vitamin A in the feed, the growth of the turkeys, the mortality, and the survival period of pen mates when placed on the vitamin A deficient basal ration.

Hinshaw and Lloyd (*9*) reported that turkeys require 1,040 gamma of carotene (1,733 International units of vitamin A) per 100 grams of feed for normal growth to 30 weeks of age. This amount is twice what they recorded for chickens. They found that chicks receiving one-half as much vitamin A in their feed as turkeys stored equally as much of this vitamin in their livers as did the turkeys.

SUMMARY

This paper contains a review of the work on vitamin A requirements of poultry. Since different workers report their results in different units of vitamin A, these units are interpolated into International units. One International unit of vitamin A is estimated to be equivalent to 0.7 A. D. M. A. unit, 0.7 Sherman Munsell unit, 0.6 gamma of Beta carotene, 0.6 microgram of Beta carotene, and 1.0 U. S. P. 1934 unit.

Symptoms of vitamin A deficiency are described in detail for chickens and turkeys, as taken from the review by Cruickshank and the work of Hinshaw and Lloyd.

Reviews are given on the vitamin A requirements of growing chicks, laying hens, and turkeys.

The reports indicate that chicks hatched from eggs laid by hens on adequate diets will grow normally with very low mortality when fed from 125 to 175 International units of vitamin A per 100 grams of feed. Those hatched from eggs laid by hens on low vitamin A diets require much more vitamin A in the feed. In fact, the mortality from such chicks is high during the first few weeks regardless of the amount of vitamin A in the feed.

From the work reviewed in this paper, it appears that for egg production when the vitamin A content of the egg is not considered, the hens should receive from 450 to 600 International units of vitamin A per 100 grams of feed. However, for breeding hens—high hatchability being a factor—or for special market eggs—a high vitamin A content of the eggs being desired—probably 1,000 International units of vitamin A per 100 grams of feed should be supplied.

Turkeys require about twice as much vitamin A as do chickens.

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VITAMIN B COMPLEX IN RELATION TO THE NUTRITION OF THE CHICK AND PIGEON

By C. W. Carter, *and* J. R. O'Brien, *The Department of Biochemistry, Oxford University, Oxford, England*

Since the classical observation of Eijkman in 1897 that a dietary factor present in rice polishings now known as vitamin B_1 was essential for normal growth and protection from polyneuritis of the fowl, considerable advances have been made. Subsequent workers have employed mainly the rat, pigeon, and chick as the subjects of nutritional research. It is probable that the nutritional requirements of these types in respect of the B vitamins are similar. These requirements are complex, and there is now evidence that not fewer than four distinct components of the vitamin B complex are essential for the normal nutrition of the pigeon and chick. The first step in the elucidation of these factors was made by Hauge and Carrick (*1*),[1] who found that a water-soluble, growth-promoting factor in addition to vitamin B_1 was required by poultry. Subsequent analysis of the "factor" of Hauge and Carrick has revealed that it is multiple. Ringrose and coworkers (*2*) observed that chicks raised on diets which had been submitted to prolonged dry heating failed to grow and developed a condition of "fowl pellagra" (chick dermatitis), which was characterized by the appearance of crusty scales and granulations at the corners of the mouth and around the nostrils and lower mandible. This condition could be prevented by the inclusion in the ration of 6 percent of autoclaved yeast, 8 percent of skim-milk powder, or 0.4 percent of a liver extract. Later, Lepkovsky and Jukes (*3*) obtained concentrates of the curative factor by submitting extract of liver to successive treatments with fuller's earth in acid reaction. The active factor, provisionally described by these workers as the "filtrate factor," was not adsorbed under these conditions and could therefore be distinguished from riboflavin and vitamin B_6, the rat antidermatitis factor of György. More recently a filtrate factor prepared by treatment of yeast and liver extracts with fuller's earth under conditions similar to those employed by Lepkovsky for the chick, has been claimed as necessary for the nutrition of the rat (*4*), pigeon (*5*), and pig (*6*). It is still uncertain whether the fuller's-earth filtrate fraction contains a single entity needed by all these types or whether several specific factors are involved. Nicotinic acid, the mammalian antipellagra factor, which is commonly present in fuller's-earth filtrates of yeast and liver, is clearly not the factor concerned here.

In addition to the antidermatitis factor, Stare (*7*) has demonstrated the need for riboflavin in maintaining satisfactory growth of the chick. Deficiency of riboflavin produces an acute paralysis with a more slowly developing "curled toe" condition (*8, 9*). Finally, several workers (*10, 11*) have observed that, on certain rations, in addition to dermatitis a type of paralysis accompanied by brain degeneration occurred which appeared to be related to the fraction of the vitamin B complex contained in autoclaved yeast and liver. The nature of this factor is still very obscure.

In the case of the pigeon, four factors, namely, vitamins B_1, B_5, B_3, and riboflavin, have been regarded as essential (*5, 12*). Deficiency of one or more of these factors, accentuating an exhaustion of the animal's own reserves, renders impossible a full restoration in weight after a preliminary period of depletion. Similarly, normal weight is not maintained indefinitely when one of these factors is lacking in the diet. The time required for the exhaustion of the bodily reserves of riboflavin and vitamins B_3 and B_5 is not yet accurately known and appears to depend not only on the degree of storage but also on the nature of the deficiency. Thus, the decline in weight on a synthetic diet supplemented by crystalline vitamin B_1 is much more rapid and severe than when vitamins B_1 and B_5 are admin-

[1] Italicized numerals in parentheses refer to Literature Cited, p. 128.

istered together. It appears certain that the pigeon can be depleted of vitamin B_1 more rapidly than of other factors, and in many cases acute polyneuritis may supervene at a time when the tissues still contain appreciable quantities of the latter. This is indicated by the fact that addition of vitamin B_1 alone in such cases may permit a large and in some cases a complete restoration of weight. In young, immature pigeons fed on a synthetic diet supplemented with vitamin B_1 alone, growth is arrested though life may be prolonged for 3 to 4 months. This result is in direct contrast to that in the chick, which rapidly succumbs under such conditions. Another point of difference is that at no stage of depletion in the young or adult pigeon has dermatitis similar to that described for the chick been observed.

Vitamin B_5 may be defined as a thermostable factor necessary for normal nutrition of the pigeon. Further evidence as to the nature of vitamin B_5 has been obtained by fractionation of a yeast concentrate or alcoholic extract of liver with fuller's earth, by the procedure of Lepkovsky, Jukes, and Krause (*13*). The fuller's-earth eluate fractions of yeast and liver provide potent sources of vitamin B_5, whereas the corresponding filtrate fractions show vitamin B_3 activity. The activity of these fractions has been tested on pigeons previously depleted on a synthetic diet which had reached a steady submaximal weight following daily additions of 40γ vitamin B_1 and 80γ riboflavin (table 1). Administration of yeast or liver eluate resulted in a response which was in all cases substantial and which in some cases resulted in complete weight restoration. The partial response of some birds is due to depletion of vitamin B_3, since further supplementation with the filtrate fractions of liver and yeast was followed by a renewed rise to the maximum attained on whole wheat. The response to the filtrate fractions alone has, in our experience, been much less conspicuous than in cases in which its administration was preceded by a supplement of vitamin B_5. It seems probable that neither of these factors can be identified with nicotinic acid or its amide since we have found that complete weight restoration invariably occurs on a maize diet following preliminary depletion, whereas the effect of administration of nicotinic amide to depleted birds has been uniformly negative.

The presence of vitamin B_5 in fuller's-earth eluates of yeast and liver suggested the possibility that this factor might be identical with vitamin B_6. A small sample of crystalline vitamin B_6, part of which was very kindly placed at our disposal by Doctor Lepkovsky, has enabled us to test this point, and also to observe its influence on the nutrition of the chick. With the pigeon, daily doses of 40γ of vitamin B_6 supplementing vitamin B_1 and riboflavin gave a response which was comparable to that observed with our eluate fractions but was less marked than when the birds were receiving, in addition, daily doses of liver filtrate. Our present data, however, although indicating the need by the pigeon of vitamin B_6, are as yet insufficient to indicate whether the whole activity of the eluate fractions can be ascribed to their content of this factor (table 2).

Finally, we have studied the influence of our preparations of vitamin B_3 (liver filtrate), vitamin B_5 (yeast eluate), and crystalline vitamin B_6 on the nutrition of the chick maintained on a basal diet similar to that used for pigeons. Chicks receiving daily supplements of vitamin B_6 (20γ) or yeast eluate in addition to vitamin B_1 and riboflavin succumbed within 28 days, a large percentage of birds developing typical dermatitis within this period. When a further supplement of liver filtrate was included, complete protection from dermatitis was afforded, and in addition there were definite prolongation of the survival period and superiority in the growth

TABLE 1.—*Effect of various supplements on gain in weight of pigeons*

Bird No.	Maximum weight	Initial weight	Final weight	Gain in weight	Period of feeding	Gain in weight per day
	Grams	*Grams*	*Grams*	*Grams*	*Days*	*Grams*
Eluate of yeast (fuller's earth)						
780	428	374	445	71	7	10.1
536	432	363	431	68	8	8.5
846	436	361	378	17	6	2.8
28	382	330	343	13	5	2.6
Eluate of liver (fuller's earth)						
568	422	374	411	37	14	2.64
782	380	305	365	60	8	7.5
814	500	314	378	64	12	5.3
536	432	326	385	59	9	6.5
Filtrate of yeast (fuller's earth)						
531	491	430	454	24	11	2.1
539	386	332	373	41	12	3.4
605	500	383	389	6	5	1.2
103	380	270	271	1	15	0
Filtrate of liver (fuller's earth)						
44	500	386	408	22	7	3.1
881	500	357	358	1	7	0
13	390	296	318	22	21	1.0
446	360	307	295	12	12	0
Eluate of liver followed by filtrate of yeast						
28	382	343	377	34	14	2.3
595	364	264	360	96	15	6.4
535	393	290	366	76	14	5.3
263	400	331	383	52	8	6.5
Filtrate of yeast followed by eluate of liver						
44	500	405	500	95	12	7.9
881	500	358	491	133	18	7.4
446	360	295	359	64	9	7.1
899	412	321	407	86	8	10.7

response. In chicks which received liver filtrate in addition to vitamin B_1 and riboflavin, protection from dermatitis was obtained but the growth response was less than half that which was observed when both filtrate and eluate were supplied (table 3). The growth observed even in the presence of eluate and filtrate was markedly subnormal when compared with that of controls on a normal diet, indicating further deficiencies, but the results appear to justify the conclusion

TABLE 2.—*Effect of crystalline vitamin B_6 on gains in weight of pigeons*

Bird No.	Maximum weight	Initial weight	Final weight	Gain in weight	Period of feeding	Gain in weight per day
Crystalline vitamin B_6						
	Grams	*Grams*	*Grams*	*Grams*	*Days*	*Grams*
1	415	339	339	0	10	0
12	460	312	347	35	11	3.0
17	436	369	399	30	12	2.5
Crystalline vitamin B_6 following liver fuller's earth filtrate						
7	422	344	420	76	11	7.0
13	390	318	350	32	11	2.9
4	460	384	434	50	11	4.5
11	490	440	455	15	9	1.8

TABLE 3.—*Average gains in weight of chicks receiving various supplements*

Supplement	21-day periods		28-day periods		34-day periods	
	Gain	Birds	Gain	Birds	Gain	Birds
	Grams	*Number*	*Grams*	*Number*	*Grams*	*Number*
B_6	9.0	5	10.2	5	8	1
Yeast eluate	24.6	5	27.4	5	......	......
Yeast eluate and liver filtrate	26.0	6	38.0	6	48.5	6
	25.4	5	42.8	5	64.6	5
B_6 and liver filtrate	17.4	5	26.0	5	28.7	4
	18.3	6	36.0	6	37.8	5
Liver filtrate	15.4	3	25.0	1	27.0	1
	10.0	5	12.0	3	14.7	3

that for the chick, as for the pigeon, vitamin B_6 is an essential dietary factor.

SUMMARY

There is now evidence that at least four distinct factors of the vitamin B complex are essential for normal nutrition of the chick and the pigeon. Using a basal synthetic diet, we have shown that the pigeon requires vitamin B_3 (filtrate fractions of liver and yeast) and vitamin B_5 (eluate fractions) in addition to riboflavin and vitamin B_1. Deficiency of these factors in the diet does not lead to dermatitis similar to that seen in the chick. Neither of these factors has been identified with nicotinic acid (or amide). It is possible that vitamin B_5 is identical with B_6. Administration of the latter in crystalline form, together with vitamin B_1 and riboflavin, gave a response similar to that obtained with yeast eluate, which is enhanced by simultaneous administration of liver filtrate. The influence of vitamins B_3, B_5, and of crystalline B_6 on chicks raised on a purely synthetic diet has also been studied. Chicks receiving 20γ B_6 or yeast eluate, together with 20γ B_1 and 40γ riboflavin succumbed within 28 days, a large percentage developing dermatitis. Addition of liver filtrate afforded protection from dermatitis, and a longer survival period and better growth were observed. Chicks receiving liver filtrate (with vitamin B_1 and riboflavin) did not develop dermatitis, but the growth response was inferior to that seen when eluate was also included. The results justify the conclusion that for the chick, as for the pigeon, vitamin B_6 is an essential dietary factor.

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A METHOD FOR QUANTITATIVE ESTIMATION OF VITAMIN D WITH GROWING CHICKS

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For estimation of vitamin D with growing chicks Massengale and Bills (1936) described a method based on the connection between the percentage of ash in the femur of the chicks and the quantity of vitamin D supplied by their feed. Grab (1936) and Olsson (1936, 1937) tested vitamin D with chicks by estimating the calcification of their intertarsal joints, as observed in X-ray photographs. By his investigations, Olsson found that the distance between the ossification zones of the distal bone in the tarsus and the metatarsus (*tmt*, fig. 1) under certain conditions is an indicator of the skeletal calcification in chicks and thus of the supply of vitamin D in their feed. An estimation of vitamin D by this method can be made as follows:

METHOD

Day-old White Leghorn chicks are fed for 7 days after hatching on a rachitogenic ration consisting of ground wheat, 30 percent; ground corn, 36; soybean meal, 16; skim-milk powder, 10; ground alfalfa hay, 6; sodium chloride, 1; powdered charcoal, 0.5; and arachis oil, 0.5 percent. This mixture contains 0.30 percent of calcium and 0.42 percent of phosphorus.

On the seventh day the chicks are divided into comparable groups for the test, which begins immediately. The percentages of calcium and phosphorus in the basal ration are increased by an addition of bonemeal; 95.6 percent of the basal ration is mixed with 4.4 percent of bonemeal (Stidvig's, containing 30 percent of calcium and 13.87 percent of phosphorus). By this means the feed will contain 1.6 percent of calcium and 1 percent of phosphorus and has a rachitic influence on the chicks but will effect good growth and health.

If the vitamin D preparations intended for the tests are oils, such a quantity of arachis oil is admixed that the total quantity of oil becomes equal for all groups. If the vitamin D preparation is a meal, its nutritive value must be estimated and a suitable substitution of other ingredients made in order to keep the nutritive value of the ration constant for the groups to be compared.

In his investigation, Olsson (1936, 1937) used a ration containing about 1.7 percent of calcium and 0.85 percent of phosphorus, which quantities seem to be most suitable for growing chicks and make them relatively insensitive to vitamin D deficiency. A comparison between the results of different rations, however, has shown that, on an intake of suitable quantities of vitamin D, the rachitogenic ration proposed earlier in this paper produces a distinct effect in 30-day-old chicks, which shows that the estimation of vitamin D may be carried out in 23 days.

Ten chicks at least should be included in each group; here as in other biological investigations the accuracy of the result is to a high degree dependent on the number of animals. From the groups of chicks series are formed for the different preparations.

The dosage of unknown preparations cannot be calculated before orientating tests are made. On standardization of the usual fish oils containing about 75 to 200 U.S.P. XI units of vitamin D per gram, the dosages given in table 1 have proved to be suitable.

On the thirtieth day after hatching one intertarsal joint of each chick is radiographed. Good photographs were obtained with a Siemens Röntgenkugel at a tension of 185 volts and an exposure of 0.4 second. If the tension is 220 volts, the exposure should be reduced to 0.1 second, though the former method is preferable.

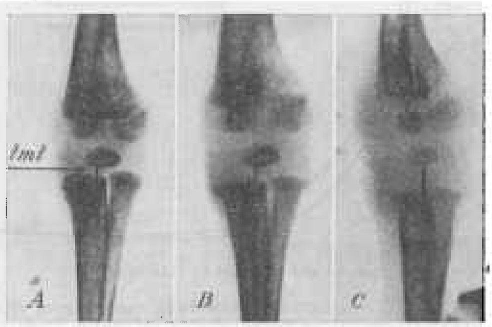

FIGURE 1.—X-ray photographs of the intertarsal joints of chicks at 30 days of age: *A*, Normal calcification; *B*, subnormal calcification; *C*, slightly rachitic. (*tmt*, tarsometatarsal distances) Enlarged two diameters.

The chicks are not anesthetized during the exposure but held in such a position that the intertarsal joint rests extended against an even surface with its front side turned toward the tube. After some training, from 100 to 150 chicks can be photographed per hour in this manner. The chicks are weighed at the same time.

After development of the X-ray photographs, the distances between the distal tarsus and the metatarsus are measured as shown in figure 1, which process is made possible by placing the film on a ground glass plate illuminated from the underside. The measurement is made with a lens that magnifies 8 to 12 times and is provided with a scale graded to 0.1 millimeter. The readings are made with an accuracy of 0.1 millimeter.

CALCULATION OF RESULT

The read *tmt* values are not only an expression for the degree of calcification but also vary with the weight of the chicks, as shown by Olsson (1936). The mean weight is lower than normal in groups that have been exposed to severe vitamin D deficiency, and their *tmt* values are on that account somewhat less than they would be if the weights of the chicks were normal. This error can be corrected by the formula

$$\frac{3W_m \times tmt}{2W_m + W_o}$$

where W_m = the mean weight for normal groups, and W_o the observed weight.

Crooked or otherwise deformed legs in chicks are no certain indication of rickets but may have another origin. Such individuals should be studied separately.

The regression of the means for corrected *tmt* values on grams of vitamin D per kilogram of feed describes a curve of logarithmic type provided the intake of vitamin D is not sufficient for all

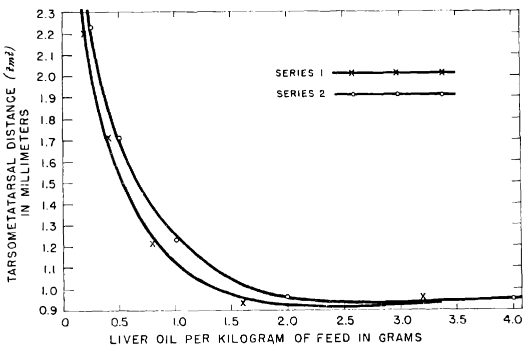

FIGURE 2.—Regression of tarsometatarsal distances on grams of liver oil per kilogram of feed.

groups. The method may be illustrated by the following example:

A comparison was made between a standardized cod-liver oil (No. 1) and another oil (No. 2) (table 1). Oil No. 1 contained about 1,200 International units of vitamin A and 200 U.S.P. XI units of vitamin D per gram. The quantity of vitamin A in oil No. 2 was determined to be about 1,000 International units per gram.

The oils were mixed with arachis oil so that all the groups received the same quantity of oil. The supply of vitamin A was made constant for all the groups by using an oil rich in vitamin A but devoid of vitamin D. Besides the vitamin A content of the basal ration, 2,400 International units of this vitamin per kilogram of feed was supplied with the oils.

The mean weights of the chicks and observed as well as corrected *tmt* distances on the thirtieth day after hatching are to be found in table 1. The *tmt* distances are corrected to a chick weight of 210 grams.

The connection between the oil ration and the means of the corrected *tmt* values for the two series is illustrated by the curves in figure 2, which are smoothed by functions according to the formula:

$$Y = a + b \log x + c (\log x)^2 + d (\log x)^3.$$

The calculation of the result may be simplified if the regression of the *tmt* means is estimated on log dose (fig. 3). The regression of corrected *tmt* values on log grams of the oil for rations insufficient for the birds' need of vitamin D will then be linear. On rations exceptionally low in vitamin D, however, some individuals will be subjected to such a vitamin D deficiency as not to be testable.

TABLE 1.—*Results obtained on chicks fed cod-liver oil No. 1 and oil No. 2*

Series and group No. of chicks	Chicks	Quantity of indicated oil per kilogram of feed: Cod-liver oil No. 1	Quantity of indicated oil per kilogram of feed: Oil No. 2	Results obtained 30 days after hatching: Mean weight of chicks	*Tmt* distances, Observed: Mean	*Tmt* distances, Observed: Standard deviation	*Tmt* distances, Corrected: Mean	*Tmt* distances, Corrected: Standard deviation
	Number	*Gms*	*Gms*	*Gms*	*Mm*	*Mm*	*Mm*	*Mm*
Series 1:								
Group No.								
1	30	0.20	......	174	2.06	0.678	2.20	0.777
2	29	.40	......	178	1.63	.412	1.71	.434
3	28	.80	......	204	1.22	.394	1.22	.409
4	30	1.60	......	216	.96	.190	.95	.169
5	30	3.20	....	210	.96	.216	.96	.201
Series 2:								
Group No.								
6	30	......	0.25	185	2.14	.740	2.23	.728
7	30	......	.50	207	1.70	.619	1.71	.710
8	30	......	1.00	222	1.26	.529	1.23	.486
9	30	......	2.00	233	1.00	.163	.96	.146
10	30	......	4.00	224	.98	.184	.95	.152

The result for these series was calculated on groups 1 to 3 and 6 to 8 (table 1), which had an insufficient supply of vitamin D. The percentage of vitamin D in oil No. 2 can be calculated from the equations of the regression lines (fig. 3).

In series 1 the mean for y (*tmt*) in the regression line is 1.721 millimeters. If this value is substituted for Y in equation 1 (fig. 3), we obtain log x = 0.6020-1 and x = 0.400 gram, which is the quantity of oil No. 1 required to give a *tmt* value of 1.721 millimeters. By insertion of the value y = 1.721 in equation 2 (fig. 3) also, the quantity of oil No. 2 required for the same result can be calculated, which is 0.501 gram. Accordingly the vitamin D strength in this oil is $\frac{0.400 \times 200}{0.501} = 160$ U.S.P. XI units per gram. The accuracy of this result must then be estimated in relation to its standard error.

ESTIMATION OF STANDARD ERROR

The standard error for a certain value log x_I on the regression line corresponding to a constant *tmt* value y_I can be calculated according to formula 1.

Formula 1

$$\epsilon^2_{(\log x_I)} = \epsilon^2_{(m_{\log x})} + \left(\frac{1}{b}\right)^2 \epsilon^2_{(y_I)} + (y_I - m_y)^2 \epsilon^2_{\left(\frac{1}{b}\right)} + \left(\frac{1}{b}\right)^2 \epsilon^2_{(m_y)}$$

The log x values of the equations are solved by equating the *tmt* value Y to 1.721; therefore, the

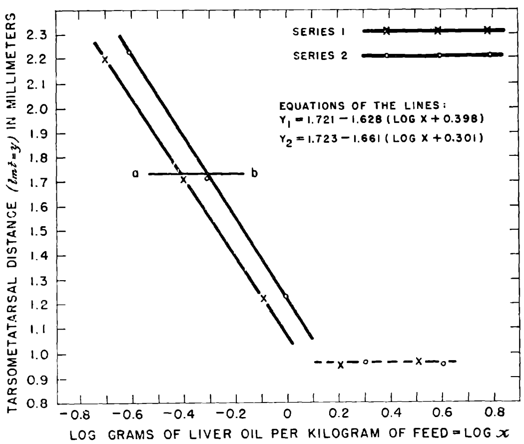

FIGURE 3.—Regression of tarsometatarsal distances ($tmt = y$) on log grams of liver oil ($= \log x$) per kilogram of feed.

term $\left(\frac{1}{b}\right)^2 \epsilon^2_{(y_I)}$ may be equated to 0. Thus, the total standard error can be calculated according to formula 2.

Formula 2

$$\epsilon^2_{(\log x_I)} = \epsilon^2_{(m_{\log x})} + (y_I - m_y)^2 \epsilon^2_{\left(\frac{1}{b}\right)} + \left(\frac{1}{b}\right)^2 \epsilon^2_{(m_y)}$$

The standard deviations (σ) for the variation in series 1 are: $\sigma_{(\log x)} = 0.226$ and $\sigma_{(y)} = 0.613$. According to the formula $\frac{\sigma}{\sqrt{n}}$ the standard errors of the means are $\epsilon_{(m_{\log x})} = 0.0242$ and $\epsilon_{(m_y)} = 0.0657$. The standard error of the coefficient of regression (b) was calculated according to the formula

$$\frac{\sigma_{(y)}}{\sigma_{(\log x)}} \sqrt{\frac{1 - r^2}{N}}$$

and is $\epsilon_{(b)} = 0.2313$. (The coefficient of correlation, r, is equal to 0.600.) The standard error for $\frac{1}{b}$ is calculated according to the formula $\frac{\epsilon_{(b)}}{b^2}$ and is $\epsilon_{\left(\frac{1}{b}\right)} = 0.0873$.

According to formula 2 the total standard error for log x_I: $\epsilon_{(\log x_I)}$ is 0.0249, when y_I is equal to 1.721. The sought value of log x_I is $0.6020-1 \pm 0.0249$ and

$$x_I \text{ is equal to } 0.400 \begin{cases} +0.024 \\ -0.022 \end{cases}$$

As oil No. 1 was standardized to 200 International units of vitamin D per gram, the requirement of this oil corresponding to the mean of the *tmt* distances, 1.721, was 80 ± 4.8 U.S.P. XI units of vitamin D.

For oil No. 2 the corresponding values, computed in the same manner, are

$$\log x_{II} = 0.7002-1 \pm 0.0297$$

$$x_{II} = 0.501 \begin{cases} +0.036 \\ -0.033 \end{cases}$$

Accordingly, 0.501 ± 0.035 gram of this oil had an effect corresponding to 80 ± 4.8 U.S.P. XI units of vitamin D.

The value of x in series 2 is not directly comparable to the corresponding value in series 1; therefore this expression in U.S.P. XI units must be transformed to a comparable value for the examined oil, i.e., be multiplied by 160. The standard error will then be ± 5.6. The total standard error for the examined oil No. 2 will then be $\sqrt{4.8^2 + 5.6^2} = \pm 7.4$. Thus, 0.501 gram of this oil contained 80 ± 7.4 U.S.P. XI units of vitamin D, or approximately 160 ± 15 per gram.

Massengale and Bills (1936) recommended a reference curve for vitamin D estimations with chicks. Coward (1937), however, has found it necessary, when standardizing vitamin D preparations with rats, to use the standard preparation also in each case. The requirements of vitamin D in chicks vary considerably from time to time: therefore, it seems inevitable that every estimation of vitamin D should be made by a direct comparison with the standard preparation.

The statistical treatment of the material has been carried out by methods recommended by Wicksell (1920) and Fisher (1930).

SUMMARY

The results of an investigation concerning quantitative estimation of vitamin D with growing chicks are as follows:

The influence of vitamin D on bone calcification in growing chicks can be studied with X-ray photographs of the elements lying around the intertarsal joint.

The distance between the calcification zones of the distal bone in the tarsus and the metatarsus (*tmt* in figure 1) is inversely proportional to the intensity of calcification in growing chicks at a

certain age. As the calcification is dependent on the vitamin D intake of the chicks, the *tmt* values, under certain conditions, may be a measure of vitamin D intake.

The suitable age of the chicks for the estimation of degree of calcification by this method is found to be 4 to 6 weeks.

Vitamin D supplements can be standardized with chicks by using the *tmt* values of the intertarsal joint as indicators of the degree of calcification, provided the vitamin D intake is sufficiently small to effect a variation in these values and a sufficient number of chicks are included in the investigation.

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NOUVELLES RECHERCHES SUR L'ÉTIOLOGIE ET LE TRAITEMENT DU RACHITISME CHEZ LES POULETS

Par Professeur Dr. G. Nichita, Dr. N. Tuschak, *et* Dr. I. Popesco, *Faculté de Médecine Vétérinaire de Bucarest, Bucarest, Roumania*

On sait que le rachitisme prend en général naissance à la suite d'une polycarence qui a pour causes directes de nombreuses insuffisances: alimentaire (protéines, graisses, hydrocarbones), minérale, vitaminique, endocrine et agents physiques.

On sait également que parmi les principales causes de dégénérescence des différentes races de poules améliorées en vue d'une production maxima en oeufs et viande, il faut tenir compte de l'alimentation des poulets insuffisante et pauvre en vitamines et en sels minéraux. L'absence des vitamines de croissance et spécialement des vitamines liposolubles, mais et surtout celle de la vitamine D et une carence en agents physiques sont les causes déterminantes qui produisent soit un arrêt de la croissance soit encore un développement vicieux du squelette avec tous les symptômes caractéristiques du rachitisme.

Dans le but d'apporter une nouvelle contribution sur l'étiologie et le traitement du rachitisme aviaire, nous avons entrepris des recherches expérimentales sur des poulets pendant les années 1936, 1937 et 1938, pour déterminer le rôle exclusif de la stabulation comme facteur rachitigène et les résultats immédiats et tardifs du traitement avec l'ergostérol irradié.

Nous avons fait une première série de recherches sur 20 poulets de race Rhode-Island-Red, éclos le 1 Mai 1936 et une seconde série de recherches sur 50 poulets de même race éclos le 8 Mai 1937. Ces deux groupes de poulets ont été élevés en liberté pendant les 30 premiers jours et se sont développés en conditions normales.

Nous avons choisi de préférence la saison chaude d'été pour ce genre de recherches afin de pouvoir utiliser le régime alimentaire vert et les agents physiques solaires éliminant ainsi les causes rachitigènes de ces carences.

Le premier groupe de 20 poulets a été divisé, à partir du 1 Juin 1936, en deux lots: le premier lot de 5 poulets témoins qui ont été élevés en continuation dans les mêmes conditions alimentaires et en liberté tandis que le reste de 15 poulets a constitué le second lot expérimental, étant élevés toujours dans les mêmes conditions alimentaires et physiques mais en stabulation, c'est-à-dire que ces poulets ont été placés, pendant un temps prolongé, dans des cages séparées de dimensions convenables sans cependant avoir trop la possibilité de faire des mouvements actifs de déplacement.

Le régime alimentaire a été établi de telle façon que les poulets aient à leur disposition une ration de nourriture et de croissance parfaitement équilibrée (équilibre protéinique, minéral et vitaminique) et possédant une valeur énergétique proportionnelle à la vitesse de croissance, calculée en calories par kilogramme de poids vif et par 24 heures. La nourriture a été administrée en 3 repas et par gavage quand la totalité de la ration n'a pas été consommée de bonne volonté.

Les recherches expérimentales sur l'influence de la stabulation sur le développement des poulets a duré jusqu'au 1 Novembre 1936, soit 5 mois. Pendant ce temps, nous avons suivi l'augmentation de poids corporel, le développement du squelette, le développement du plumage, les variations de température corporelle, le métabolisme basal et le métabolisme alimentaire (action dynamique spécifique des aliments).

L'espace limité réservé à ce rapport ne nous permet d'exposer que les résultats obtenus dans la croissance et le développement du squelette.

Le lot témoin a grandi et s'est développé normalement atteignant un poids corporel moyen de 2850 gr. (fig. 1), tandis que le lot expérimental était complètement dégénéré. En effet, le poids moyen des poulets de ce second groupe a atteint à peine 1330 gr., donc leur croissance a été nettement sous-normale et les processus d'ossification ont été si défectueux que chaque poulet présente des lésions profondes de rachitisme expérimental à différents degrés et avec une symptomatologie très variée. Certains poulets ont une marche normale mais leurs pattes sont développées defectueusement parce que les os du tibia et métatarse sont arqués en dedans ( ) ou en dehors) (. Il y a d'autres poulets qui sans présenter de déformation osseuse apparente montre une grande gêne pour la marche lente et une impossibilité de déplacement à une vive allure. Enfin, il y en a d'autres encore qui relèvent brusquement les pattes du sol et font des sauts spontanés ce qui dénote surtout une réaction aux douleurs intra-articulaires. En effet, dans ce cas les articulations sont déformées, tuméfiées, chaudes et très sensibles à la palpation. Certains autres poulets présentent une symptomatologie beaucoup plus alarmante, ils ne peuvent plus tenir sur leurs pattes et ne peuvent pas marcher du tout; si nous les forçons, ils se déplacent très difficilement et très souvent malgré leurs efforts ils ne réussissent qu'à faire quelques pas sur le métatarse pour tomber ensuite immédiatement sur le côté et rester ensuite tout le temps couchés en décubitus sternal ou latéral. De plus, ils ne mangent pas du tout et nous sommes obligés de les gaver.

Pendant le mois de Novembre 1936, tous ces 15 poulets ont été photographiés et en même temps on a fait la radiographie de leurs membres inférieurs. C'est surtout l'étude radiographique qui nous fournit la possibilité de suivre l'évolution du rachitisme expérimental. Les membres inférieurs et spécialement les os longs de la région tibio-métatarsienne se prètent admirablement à cette étude pour les poulets. On observe une différence remarquable entre le lot témoin et le lot rachitique. Les os longs des poulets témoins sont bien développés, droits, compacts et les cartilages de conjugaison entre la diaphyse et l'épiphyse ont disparu. L'os est complètement consolidé. Au contraire, ces régions osseuses chez les poulets rachitiques sont mal développées, déformées, poreuses, la diaphyse est séparée de l'épiphyse par un espace cartilagineux hyalin de 5 à 7 millimètres. Il est question d'un rachitisme grave avec un élargissement anormal de la zône de croissance cartilagineuse, notamment au niveau de la tête inférieure du tibia et de la tête supérieure du métatarse (fig. 1).

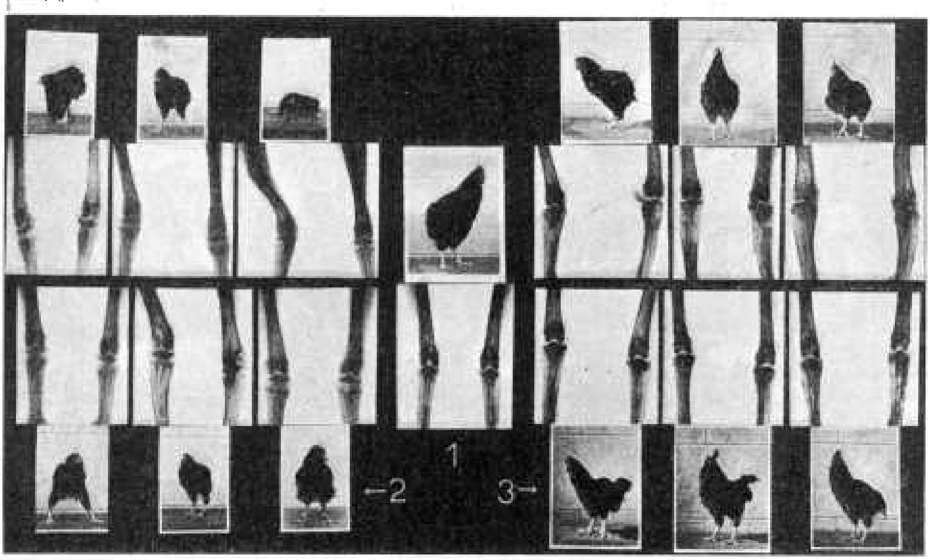

FIGURE 1.—Photographie des poulets et radiographie de la région tibio-métatarsienne (1936): 1, Lot témoin; 2, lot rachitique avant le traitement; 3, lot rachitique après le traitement à l'ergostérol irradié.

Au cours de ce même mois, tous les poulets rachitiques ont été soumis au traitement journalier à l'ergostérol irradié, pendant 3 mois (18.XI.1936-18.II.1937). Ils ont été nourris avec le même régime alimentaire et tenus en liberté tout comme le lot témoin.

Nous avons étudié la croissance en poids, le développement corporel et la maturité sexuelle ainsi que les modifications du métabolisme énergétique par la mesure du métabolisme basal et alimentaire. Nous avons surtout étudié le processus d'ossification et l'amélioration des lésions rachitiques à l'aide d'une deuxième radiographie après un mois de traitement et par une troisième et dernière radiographie effectuée à la fin de ces trois mois de régime antirachitique. Des résultats obtenus nous ne donnerons ici que l'augmentation de poids, l'amélioration de l'état général des poulets et l'aspect radiographique du processus d'ossification.

Le poids corporel moyen du lot rachitique était au début du traitement de 1330 gr., le poids individuel variant de 860 gr. à 1850 gr.; à la fin du traitement il atteint la moyenne de 2120 gr. avec une variabilité individuelle de 1830 à 2570 gr. On obtient donc une augmentation considérable de poids corporel qui va du simple au double pour certains poulets, l'augmentation moyenne étant de 800 gr. avec un maximum de 1250 gr. Ce sont surtout les poulets les plus dégénérés d'un poids de 860 gr. qui ont augmenté de 1200 gr. en 3 mois, soit avec un pourcentage d'augmentation de 150 pour-cent.

Le lot témoin a augmenté aussi pendant ce temps de 400 gr., ayant un poids moyen de 3250 gr.

En même temps, on constate une amélioration appréciable dans la symptomatologie du rachitisme; elle est plus rapide chez les poulets plus légèrement atteints et plus lente pour ceux qui possèdent des lésions osseuses et intra-articulaires. Les poulets commencent à se tenir sur leurs pattes, puis commencent à faire quelques pas en chancelant, puis peu à peu deviennent plus sûrs et à la fin du traitement ils peuvent courir avec une certaine aisance.

Les tuméfactions articulaires ont diminué et la sensibilité douloureuse des articulations tibio-métatarsiennes a disparu. Les déformations osseuses et articulaires se sont, en partie, améliorées.

L'état général et l'aspect du plumage riche et luisant nous montrent une transformation complète du lot rachitique. Enfin, les épreuves radiographiques dénotent un procès actif d'ossification pendant le traitement et une consolidation parfaite après 3 mois. La zône du cartilage de conjugaison diminue progressivement et la dernière radiographie nous montre la soudure complète de la diaphyse avec les épiphyses de telle sorte qu'on n'observe aucune différence entre cette radiographie et celle des poulets témoins.

Les résultats obtenus à l'aide de l'ergostérol irradié ont été d'autant plus concluants que le traitement a eu lieu en plein hiver donc carence complète en agents physiques (lumière solaire, rayons ultra-violets) et manque d'alimentation fraîche (luzerne, trèfle, etc.).

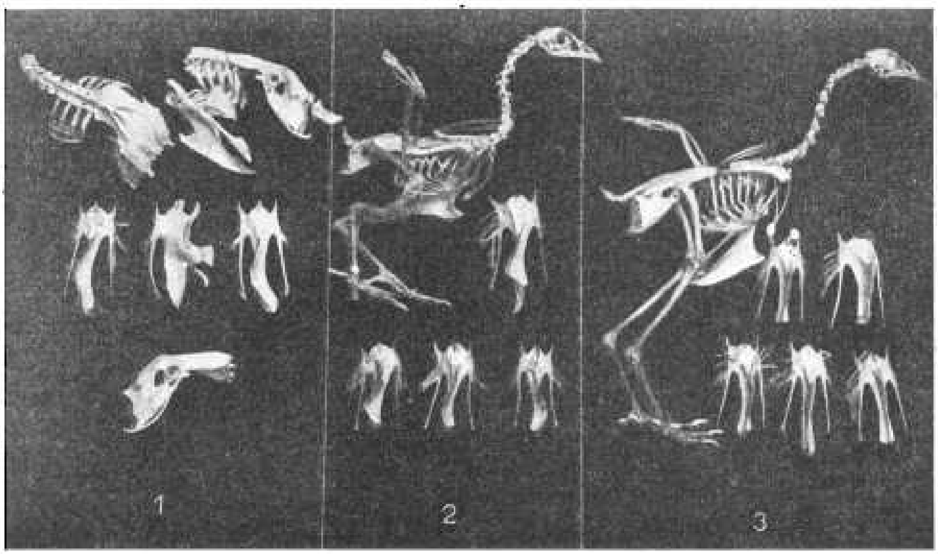

FIGURE 2.—Photographie du squelette des poulets: 1, Cage thoracique, sternum et bassin du lot rachitique 1936 après un ou deux ans; 2, squelette et sternum des poulets du lot rachitique 1937; 3, squelette et sternum des poulets du lot témoin 1937.

Ce lot expérimental a été étudié par la suite pendant les années 1937 et 1938. En dehors des troubles constatés à cause des déformations permanentes squelettiques, ces poules ont conservé un état d'entretien relativement bon et la moitié d'entre elles ont été sacrifiées à l'âge de un an et demi (1.XI.1937) et le reste à l'âge de deux ans et demi (1.XI.1938) pour l'étude du squelette. Le lot témoin a été également sacrifié pour permettre l'étude comparative.

A notre grande surprise, nous avons constaté à l'autopsie du lot rachitique des déformations osseuses beaucoup plus graves quant au squelette de la cavité thoracique (colonne vertébrale, côtes et sternum) et de la région pelvienne (ilium, ischium et coccyx) que pour celui des membres inférieurs, comme on peut le voir su les photographies ci-jointes (fig. 2).

Les côtes sont arquées en dedans avec de nombreuses nodosités dans leur portion sternale, on remarque aussi les plus curieuses torsions du sternum ce qui diminue le volume de la cage thoracique. La colonne vertébrale est fortement incurvée dans la région pelvienne, réduisant à moitié le diamètre antéro-postérieur de la cavité abdominale; l'animal présente même à l'extérieur une sorte de bosse, les os du bassin formant un angle presque droit avec la portion terminale de la colonne vertébrale, (fig. 2).

Nous avons fait une deuxième série de recherches en 1937 sur un nombre de 50 poulets de race Rhode-Island-Red, dans le but de vérifier les résultats antérieurs seulement en ce qui concerne le rôle rachitigène de la stabulation.

Les poulets ont été répartis en deux lots de 25 à l'âge d'un mois (8.VI.1937) un lot témoin élevé en liberté et un lot expérimental élevé dans les mêmes conditions de stabulation que celui de l'année précédente. Le régime alimentaire a été le même pour les deux lots et les recherches expérimentales ont duré 5 mois (8.XII.1937). Les résultats obtenus tant à la croissance qu'au développement du squelette sont absolument comparables à ceux des premières recherches. A l'âge de 6 mois (8.XI.1937), tous les poulets étaient rachitiques. Nous les avons sacrifiés et leur squelette a été préparé. Les différences entre le lot témoin et le lot expérimental (fig. 2) sont les preuves éloquentes du rôle de la stabulation comme nouveau facteur rachitigène. Les déformations rachitiques récentes constatées à l'autopsie sont identiques à celles constatées tardivement après un ou deux ans chez les poules des recherches de 1936.

CONCLUSIONS

De l'ensemble de nos recherches expérimentales effectuées sur 70 poulets de race Rhode-Island-Red, nous tirons les conclusions suivantes:

1. L'une des causes déterminantes du rachitisme des jeunes volailles, outre les insuffisances alimentaires, minérales, vitaminiques, endocrines et physiques, est la stabulation c'est-à-dire le séjour prolongé des poulets dans un espace restreint, les empêchant de se mouvoir en liberté. Les poulets sont extrêmement sensibles et constituent un réactif animal admirable pour l'étude de ce genre de rachitisme expérimental qui peut produire des lésions très variées et graves en rapport avec la durée de la stabulation.

2. L'ergostérol irradié utilisé comme traitement de ces poulets rachitiques et la vie en liberté nous ont donné d'excellents résultats; nous avons obtenu, en effet, avec ces facteurs, une reprise de la croissance et une ossification complète avec la soudure parfaite de la diaphyse avec les épiphyses des os longs constatée à l'examen radioscopique et sur les épreuves radiographiques.

3. Les déformations osseuses constatées à l'autopsie des poulets rachitiques par stabulation persistent même après le traitement à l'ergostérol irradié. Elles sont consolidées grâce au processus actif d'ossification—oeuvre des ostéoblastes—sans qu'il se produise, en même temps, un processus de remaniement osseux profond—oeuvre des ostéoclastes—qui pourrait réaliser le redressement des os. C'est pour cette raison que les squelettes des poules sacrifiées après un ou deux ans présentent les mêmes déformations osseuses graves que celles constatées immédiatement après les 5 mois de stabulation comme on le voit dans la seconde série de recherches.

(Travail du laboratoire de Physiologie générale et spéciale).

RÉSUMÉ

Nous avons entrepris des recherches expérimentales sur des poulets dans le but de déterminer le rôle exclusif de la stabulation, comme facteur rachitigène, ainsi que les résultats du traitement à l'ergostérol irradié.

Nous avons fait une première série de recherches, en été 1936, sur 20 poulets parmi lesquels 5 ont été élevés en liberté et 15 en stabulation. La ration alimentaire a été complète et parfaitement équilibrée et la lumière solaire suffisante.

Après 5 mois tous les poulets en stabulation présentent des lésions rachitiques graves et on leur administre journellement de l'ergostérol irradié pendant 3 mois. Leur état général s'est amélioré, leur poids corporel a doublé et les épreuves radiographiques prouvent un processus d'ossification actif avec la soudure de la diaphyse et des épiphyses.

Nous avons sacrifié ces poules à l'âge de un an et demi et deux ans et demi et nous avons constaté des déformations osseuses graves, ce qui nous montre que le traitement antirachitique a consolidé le squelette antérieurement déformé, grâce à l'activité des ostéoblastes sans réaliser, en même temps, un processus de remaniement osseux—oeuvre des ostéoclastes—qui aurait provoqué un redressement des os.

Nous avons fait une seconde série de recherches en été 1937, sur 50 poulets, 25 élevés en liberté et 25 en stabulation. Les conditions expérimentales étant les mêmes, après 5 mois tous les poulets élevés en stabulation sont devenus rachitiques. Nous avons sacrifié l'effectif entier pour l'étude du squelette. Les déformations rachitiques constatées à l'autopsie sont identiques à celles observées sur les poules sacrifiées après un ou deux ans, dans notre première série de recherches. Nous croyons donc avoir établi ainsi, expérimentalement, le rôle de la stabulation comme facteur rachitigène chez les poulets.

SUMMARY

Experimental studies were conducted with chickens to determine the role of confinement as a rachitis-producing factor and to ascertain the results obtained by treatment with irradiated ergosterol.

The first series of investigations was made in the summer of 1936 with 20 chickens, 5 of which, from the time of hatching, were permitted to move about freely, and 15 were confined in individual cages. The diet was complete and perfectly balanced and sunlight sufficient.

After 5 months, all confined chickens showed serious rachitic injuries. They were given irradiated ergosterol daily for a period of 3 months. Their general condition improved, their weight doubled, and X-ray plates showed an active ossification process, bringing about the joining of the diaphysis and the epiphysis.

When these chickens were killed at the ages of 1½ and 2½ years, serious bone deformities were found. This shows that the antirachitic treatment had consolidated the previously deformed skeleton through the activity of the osteoblasts. At the same time, however, the treatment did not result in a process of osseus repair—the action of the osteoclasts—which would have caused a straightening of the bone.

A second series of studies was begun in the summer of 1937 with 50 chickens, 25 being raised unconfined and 25 confined in cages. Conditions were the same as in the previous experiment. After a period of 5 months all the chickens reared in confinement became rachitic. The entire lot was killed in order to make a study of the skeletons. The rachitic deformations noted post mortem were identical with those observed in chickens killed at 1½ and 2½ years of age in the first series of studies. We therefore believe that in these experiments we have established the role of confinement as a rachitis-producing factor in chickens.

PHOSPHORUS METABOLISM IN NORMAL AND RACHITIC CHICKENS WITH A RADIOACTIVE PHOSPHORUS ISOTOPE AS AN INDICATOR

By M. J. L. Dols, *Laboratory of Physiological Chemistry, University of Amsterdam, Amsterdam, The Netherlands*

Since 1935 we have made use of a radioactive phosphorus isotope as an indicator in experiments on phosphorus metabolism in normal and rachitic rats and chickens.[1] With this isotope it is possible to "label" the phosphorus of the diet and to follow this phosphorus on its way through the organism. In this manner, we first investigated the absorption, retention, and deposition of phosphorus in the bones of 60 normal and rachitic rats. It was observed that the distribution of the phosphorus in the organism could be followed up easily; almost all the active phosphorus administered could be recovered. A very rapid entrance of the "labeled" phosphorus into the bone was perceptible in all cases. Furthermore, it was found that 1 hour after the injection of the phosphorus into the tail vein, a considerable quantity of the active phosphorus was re-excreted into the small intestine, whereas the phosphorus in the blood had disappeared entirely in several rats. So far as absorption was concerned, no difference could be observed in the normal and rachitic rats, whereas the same statement does not apply to re-excretion into the gut.[2, 3]

In further experiments with 90 rats, the formation of lipin phosphorus was investigated. It was clearly established in these experiments that in the first half hour after the injection of the phosphorus no difference exists between the normal and the rachitic rats. However, in rats decapitated 1, 3, or 20 hours after the injection of the active phosphorus, there is a significant difference, in favor of the rachitic rats, in the quantity of the injected phosphorus present in 1 mg of the lipin phosphorus.[4, 5] Therefore, it seems that an increased formation or a decreased destruction of lipin phosphorus takes place in rachitic animals. The experiments on this subject are being continued.

After the rat experiments had shown that it is possible to use the radioactive phosphorus isotope in physiological work, we began to investigate the distribution of phosphorus in the leg bones and several organs of normal and rachitic chickens after intraperitoneal injection of labeled sodium phosphate.

In the first series, a fixed quantity of the active sodium phosphate, as an aqueous solution of pH 7.2, was injected intraperitoneally in eight chickens. The chickens were decapitated 22 hours after the injection and quickly sectioned. The leg bones were then dissected and cleaned. One of the leg bones of each bird was then divided into three parts, namely, the proximal epiphysis, the distal epiphysis, and the diaphysis. The two epiphysial parts of the bone were then carbonized together in an oven at 200° C. The same proce-

[1] Sixth World's Poultry Congress (Leipzig) 3:198. 1936.
[2] Nature 139:1,068. 1937.
[3] Roy. Acad. Proc. (Amsterdam) 40:547. 1937.
[4] Nature 141:77. 1938.
[5] Roy. Acad. Proc. (Amsterdam) 41:997. 1938.

dure was followed with the diaphysis. No phosphorus was lost in this procedure. Then for the determination of the radioactivity, a preparation of the epiphysial part and a preparation of the diaphysial part were made from the leg bone of each chicken. Therefore, the residue of carbonization was pulverized, sieved, and suspended in ether. The suspension was poured out into a flatly ground ring of glass, which was placed on a tared aluminium foil. The ring was pressed on the foil by loading it with a weight or another object, to prevent the ether from flowing away. Then the ether was evaporated at room temperature, after which a flat layer of the residue of carbonization with uniform thickness remained on the foil. Next the foil, with the layer, was weighed and the activity measured. In addition, a part of the residue of carbonization was used for the estimation of the total phosphorus according to Fiske and Subbarow.

Determination of the radioactivity was made with an ionization chamber, whereby the ionization current produced by the β-particles emitted by the radioactive phosphorus in the bone preparations was compared with the ionization current of a constant source—in this case the γ-activity of a piece of pitch blend. Because the β-particles are partly absorbed in the preparation itself, a correction should be made in the estimated activity. Finally, the activity of all preparations had to be corrected for the decay of the phosphorus. The half-value period of the radioactive phosphorus was determined to be 15 days. In our experiments all the activities were reduced to the moment at which the activity of the solution administered was measured.

The provisional figures of this experiment showed that the phosphorus content of the dried matter in the epiphysial part and in the diaphysial part is larger in normal than in rachitic chickens. Furthermore, it was established that in both normal and rachitic chickens the phosphorus content of the diaphysial part of the bone seems to be larger than that of the epiphysial part of the same bone.

With regard to the distribution of the active phosphorus administered, it was observed that in both normal and rachitic chickens decapitated 22 hours after the injection of the active phosphorus, the quantity of the active phosphorus in 1 mg of bone phosphorus was larger in the epiphysis than in the diaphysis. Furthermore, it was observed that both the epiphysis and diaphysis of the rachitic birds decapitated 22 hours after the injection of the labeled phosphorus contained a much larger quantity of the active phosphorus in

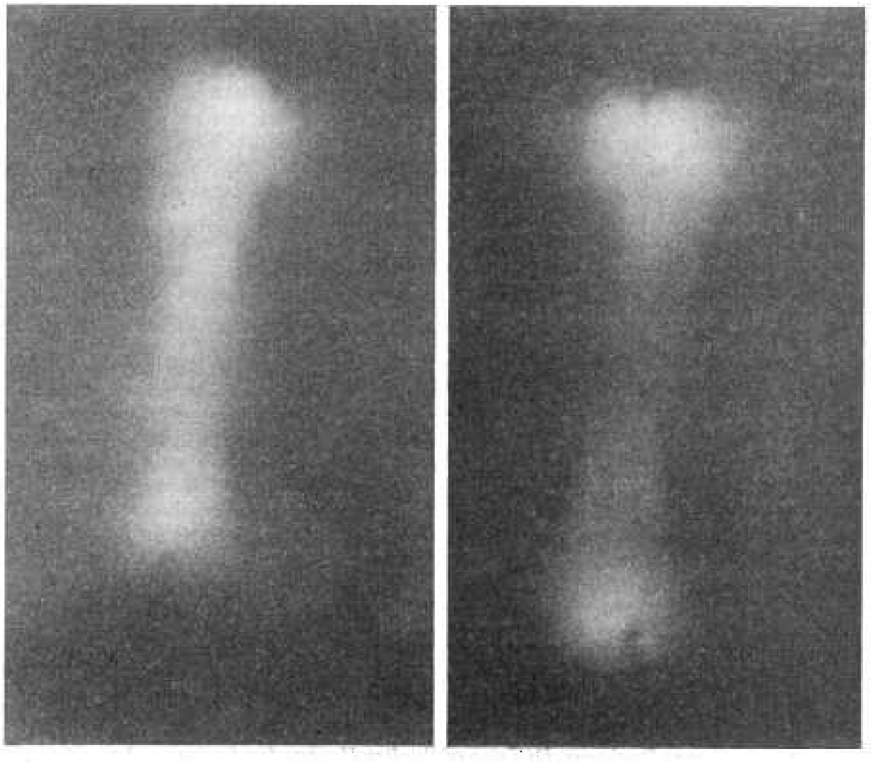

FIGURE 1.—Phosphorus distribution in tibia of rachitic chicken (left) and normal chicken (right) as shown by X-ray. It is evident that the epiphysial parts contain more of the active phosphorus than do the diaphysial parts.

1 mg of bone phosphorus than did the epiphysis and diaphysis of the normal chickens.

In a second series of experiments with 30 birds, our investigations were continued and repeated. A fixed quantity of the active phosphorus again was injected intraperitoneally as an aqueous solution of sodium phosphate of pH 7.2, and the chickens were decapitated 22 hours after the injection and sectioned. Besides the leg bones, the liver and the spleen were analyzed. In this series, the radioactivity of four preparations of a leg bone of each chicken was measured, namely, the proximal epiphysis, the distal epiphysis, the diaphysis, and the lipin fraction of the whole leg bone. The preparations to be measured were made in the manner described previously. A part of the residue of carbonization was used for the determination of the phosphorus content of the several parts of the bone. The liver and the spleen were dissected, dried in an oven at 105° C., pulverized in a mortar, sieved, and suspended in ether, after which the preparations were made in the manner described for the bone preparations. A part of the dried powder was used for the chemical estimation of phosphorus.

As the chemical estimations in this series were not finished when this paper was prepared, it was impossible to calculate the quantity of the active phosphorus in 1 mg of bone phosphorus of each part of the bone. The provisional figures indicate, however, that the results of this series are fully in accordance with those of the first series. The phosphorus content of the dried matter in the epiphysial part and in the diaphysial part is larger in the normal than in the rachitic chickens, and the diaphysial part seems to have a larger phosphorus content than the epiphysial part. With regard to the distribution of the active phosphorus in the bone, it was found that the activity of the lipin fraction was very low; nevertheless, this activity seems to be greater in the rachitic than in the normal chickens. The spleen preparations showed hardly any activity, whereas the liver preparations were very active. As was indicated previously, differences in the activity per milligram of phosphorus could not be calculated when the paper was prepared.

In both series of experiments the second leg bone of each chicken was not carbonized, but after being cleaned it was placed on a double-coated X-ray film. It remained there for some days, according to the quantity of active phosphorus injected. The film was then developed; a clear picture of the whole bone was visible, as is shown in figure 1. This figure shows convincingly that the epiphysial parts of the bone contain a larger quantity of the active phosphorus than do the diaphysial parts. These observations are fully in accordance with the measurings of the radioactivity of the several parts of the bone.

SUMMARY

Experiments are described in which the distribution of phosphorus in the leg bones, the liver, and the spleen of chickens was investigated, a radioactive phosphorus isotope being used as an indicator. Though the chemical analyses were not finished when the paper was prepared, the provisional results showed differences in the distribution between normal and rachitic chickens.

A method also is described by which it is possible to photograph the distribution of the active phosphorus in the leg bones of chickens. These pictures are fully in accordance with the measurings of the activity in the preparations themselves.

PROPERTIES OF VITAMIN K

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There may be found in the literature, prior to 1935, several accounts (*16, 17, 18, 32, 33, 35, 36*)[1] of experimentally induced dietary alterations in the blood-clotting power of the chicken, which may now be interpreted in terms of the antihemorrhagic vitamin.

In 1935 papers by Dam (*19*) and by Almquist and Stokstad (*8*) furnished adequate evidence of the existence of an antihemorrhagic factor with the characteristics of a vitamin. Since these reports, the knowledge of the properties of vitamin K has rapidly expanded. The earlier work on vitamin K has been reviewed elsewhere (*2*).

[1] Italicized numerals in parentheses refer to Literature Cited, p. 141.

ASSAY METHODS

The quantitative estimation of vitamin K is based on the blood-clotting power and may be conducted by either curative or preventive procedure (*7, 11, 21, 39, 42*). The methods proposed have varied from simple measurement of blood-clotting time (*11*) to most elaborate techniques (*21, 39*) for obtaining blood samples and measuring blood-clotting power with standardized clotting preparations. It has been shown that, over a practical range of blood-clotting times, the reciprocal of the clotting time bears a linear relation to the logarithm of the vitamin K concentration in the diet (*7*). Thus interpolation of assay tests in terms of a reference standard is greatly facilitated.

Since the vitamin is not a growth factor and does not affect feed consumption, it is sufficiently accurate and considerably more convenient to give the vitamin by admixture with the diet rather than by individual dosage.

OCCURRENCE AND DISTRIBUTION

Vitamin K is relatively abundant in green leafy tissue (*8, 19, 20, 26*), commercially dried alfalfa serving as an excellent practical source. It is destroyed in dried alfalfa when exposed to sunlight (*3*). However, the natural withering process in chestnut leaves does not seem to reduce the content of the vitamin per gram of dried substance (*20*). The tops of carrots are good sources of vitamin K, whereas the roots contain no detectable quantity (*3*), thus furnishing a marked contrast with the distribution of carotene in the same plant. Such a result also suggests that the vitamin is richest in the photosynthetically active portion of the plant. The observation (*20*) that there is abundant synthesis of the vitamin in peas grown in the light but only a very limited synthesis in the dark is further evidence in the same direction.

Occurrence to a lesser extent has been reported in various other portions of plants. Among the moderately good sources are the tomato, hempseed, and seaweed (*20*), soybean and soybean oil (*11, 20*).

Following early observations on the synthesis of vitamin K during the spoilage of feedstuffs (*8*) and in the droppings and probably the lower intestinal tract of chicks (*11*), presumably by bacterial action, it has been reported (*13*) that a number of bacteria, including the very common *Bacterium coli*, *Bacillus cereus*, and *Bacillus subtilis*, synthesize a fat-soluble antihemorrhagic factor and apparently do not release or excrete it into the media on which they are grown. The dried bacteria are five to eight times as potent as dried alfalfa. Certain species of bacteria were found that did not possess any measurable activity and, in general, micro-organisms of the mold, yeast, or fungus types were also inactive.[2] Limburger cheese, a food rich in bacterial products, was quite active. Acidophilus milk and buttermilk, on the other hand, contained no detectable antihemorrhagic potency probably because of a relative absence of K-forming bacteria. Bacterial putrefaction of fish meal has been successfully employed in the preparation of vitamin K concentrates (*8, 37*).

In the egg the vitamin is localized in the yolk (*10*). The reserve store in the newly hatched chick is influenced by the level of vitamin K in the diet of the parent hen (*10*). Peculiarly enough, the liver of young chicks contains very little (*10, 23, 26*), whereas in the hog (*26, 29*) the liver fat is a good source. Data on the vitamin K content of mature bird's liver are not available. A preliminary investigation of the distribution of vitamin K in the body of the young chickens has been reported (*24*).

PHYSICAL AND CHEMICAL PROPERTIES

Knowledge of the physical and chemical properties of vitamin K up to the middle of 1938 has been condensed into the following paragraphs.

Form.—Most active concentrates have been viscous oils at room temperature (*1, 25, 26*). The vitamin has been obtained as a colorless solid by repeated crystallization from methyl alcohol at very low temperatures (*3*). This preparation may have been the pure vitamin or a mixture of uniform composition. Since it is difficult to choose between these possibilities by means of the physical methods employed in the isolation of the vitamin, additional purification procedures must be found.

It has been claimed that a preparation of vitamin K made by similar methods was the pure vitamin. A melting point of 69° C. was reported for the crystalline, vitamin K fraction (*40*). It is obvious, however, that the same uncertainties as to complete purity apply also in this case.

Color and optical activity.—Very active preparations have been obtained which are practically colorless (*3, 4*), indicating that the vitamin probably bears no close resemblance in structure to the fat-soluble plant pigments. It also appears to be optically inactive (*4*).

Solubility.—The vitamin is very soluble in the less polar organic fat solvents but also readily soluble in more polar solvents (*1, 26*). It tends to remain dissolved in alcohols even while sterols and fats are being crystallized by cooling (*3, 25, 26*).

Volatility.—Sublimation of the vitamin under greatly reduced pressure can be accomplished at comparatively low temperatures of 120° to 160° C. (*1, 25*). This property has proved to be of value in purification.

Molecular weight.—Determinations of molecular size made on the purest concentrate yet obtained gave an average value of 525 (*34*). This, of course, is entirely a preliminary estimate since the purity of the vitamin was not known, but the high value does indicate a complex structure.

Elementary composition.—The vitamin contains no sulphur, phosphorus, or nitrogen (*3, 4*).

Structure.—Presence of an aromatic nucleus is strongly indicated by positive responses to the well-known nitration test and by ready condensation with aluminum chloride (*4, 34*).

Activity of concentrates is easily destroyed by brief contact with dilute bromine but not with iodine (*4, 34*). The irreversible nature of the destruction by bromine suggests that addition or substitution of bromine probably occurs in the aromatic portion (*34*). The vitamin is also destroyed by hydrogen iodide and by hydrogen sulphide, probably through addition at unsaturated linkages (*34*).

Oxidizing agents, perbenzoic acid, nitric acid,

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[2] Unpublished data of the author, with C. F. Pentler and E. Mecchi.

chromic acid, and ferric chloride, have destructive action (*4, 34*), although heating concentrates of the vitamin in air at 100° C. or more does not appear to affect it (*1, 8, 19, 26*). Metallic iron in acetic acid and stannous chloride, as reducing agents, were not destructive to the vitamin (*34*).

Reagents that attack alcoholic hydroxyl groups, specifically phenyl isocyanate, 3,5-dinitrobenzoyl chloride, benzoyl chloride, acetic anhydride, and cyanic acid, failed to alter the observed properties or activity of the concentrates (*4, 25, 34*), and it seems clear that the vitamin contains no alcoholic group.

The failure similarly of 2,4-dinitrophenylhydrazine (*4*) of trimethyl-acethydrazide-ammonium chloride (*25*) and of hydrogen cyanide (*34*) indicates a lack of ketone groups. Furfural and formaldehyde are likewise not detrimental to the vitamin and, evidently, phenolic or other structures which these aldehydes attack are also absent (*34*).

The instability of the vitamin to alkaline hydrolysis has been repeatedly confirmed (*1, 4, 26, 29*).

In general, the known properties of the vitamin are consistent with those of a complex, unsaturated hydrocarbon of low melting point.

PHYSIOLOGICAL PROPERTIES

A severe deficiency of vitamin K in the chick leads to a greatly prolonged blood-clotting time and often a spectacular condition of subcutaneous and intramuscular hemorrhage accompanied by a resultant anemia. Administration of the vitamin restores blood-clotting power to normal, reabsorption of the hemorrhagic blood follows rapidly, and the hemoglobin level becomes normal.

Intramuscular or intravenous injections of a watery emulsion of the vitamin are effective, but subcutaneous injections of an emulsion are comparatively ineffective. However, subcutaneous injections of a complex of the vitamin with deoxycholic acid, dissolved in weak alkali, are successful. By intravenous injection, blood-clotting power of the chick may be rendered normal in about 5 hours (*24*). Oral administration of the vitamin to the chick also decreases blood-clotting time to normal within 4 to 6 hours when a sufficient quantity is given (*14*).

Concentrates of the vitamin in contact with plasma or whole blood from deficient chicks have no power to accelerate clotting (*24, 28, 39*). It seems evident that a metabolic process is involved before vitamin K may become physiologically active. For example, the prothrombin fraction of the chick's blood diminishes on a subadequate vitamin K intake and rises again within a few days after the deficiency has been corrected (*38, 39*). It has been reported that vitamin K appears to be firmly combined in the prothrombin fraction of chicken blood (*28*), although later studies seem to indicate that the prothrombin fraction contains little vitamin K (*24*).

No other blood components seem to be abnormal in vitamin K deficiency when hemorrhage is absent (*5*). Hemoglobin level, in particular, is not affected except secondarily as a result of hemorrhage (*7, 11, 12, 39*). Certain workers (*41*), however, have claimed that anemia may be a direct consequence of a vitamin K deficiency.

Erosions or lesions of the gizzard lining were noted in early reports (*16, 17, 18, 19, 32*) and included as a portion of the deficiency syndrome. It was suggested (*8*) and later proved (*9*) that the gizzard defects were a separate disease. They are now known to be related to a deficiency of certain components of bile, particularly cholic acid (*5, 6*). Like vitamin K deficiency, the gizzard erosions seem to have no appreciable influence on rate of growth.

Since the early work on the chick, which still seems the most sensitive experimental animal in vitamin K studies, it has been established that several other species of birds, including the duck, goose, canary, and pigeon (*27*) and the turkey, as found by the author,[3] are subject to the same deficiency disease.

Importance of the factor to mammals was difficult to demonstrate merely by eliminating the vitamin from the diet (*27*). This difficulty may have been entirely or largely due to failure to deplete the reserve stores of the vitamin in the animal. Then, too, there is the possibility of bacterial synthesis of vitamin K in the gut (*10, 13*), some of which may be absorbed. It has been recently reported that the rabbit may develop a mild K-avitaminosis on a K-free diet (*22*).

Animals in certain abnormal physiological states, however, have provided strong evidence that vitamin K is a vital factor for mammals. Rats (*30*) and dogs (*31*) deprived of bile by bile fistula show loss of blood coagulability and a low prothrombin level. It is further known that this condition in such rats is relieved by oral administration of vitamin K, but not efficiently unless accompanied by bile or bile salts (*30*). In man, obstructive jaundice leads to an analogous condition involving similar blood defects which may be similarly cured (*15, 22, 43*). The administration of bile alone has long been known to restore normal blood coagulability in patients suffering from obstructive jaundice, and an explanation for this fact is now at hand, namely, that bile is necessary for efficient absorption of vitamin K. In the absence of bile, although ample vitamin K is in the diet, the animal is likely to become deficient through failure of absorption (*30*). In fact, an artificial bile-duct obstruction in the chicken will eventually cause it to show vitamin K deficiency while being fed a normal diet (*22*).

By direct injection the necessity for simultaneous bile administration is avoided, and both the animals on a vitamin K-free diet and patients in a condition of obstructive jaundice may be cured of the blood coagulation defects resulting from vitamin K deficiency (*23*).

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[3] Unpublished data.

SUMMARY

Methods of biological assay, the occurrence and distribution, the physical and chemical properties, and the physiological properties of vitamin K are reviewed.

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PROTEIN REQUIREMENTS OF CHICKS

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INTRODUCTION

Lack of agreement on the optimum protein requirements as reported by different workers may be due to differences in the kinds of proteins studied, the vitamins and minerals in the protein supplement, and the basal diets used. In protein-requirement studies of chicks conducted in batteries by Carver and coworkers (1931), it was found that 18 percent of protein in the diet for the first 6 weeks, 15 percent from 7 to 12 weeks, and 13 percent from 12 weeks to maturity supplied the most efficient and satisfactory growth. As skim milk was used as a source of protein, riboflavin was no doubt supplied in adequate quantities, although vitamin A and the minerals were not adjusted in the diet as the requirements were not known at that time.

Norris and Heuser (1930) and Heuser and Norris (1931) found that chicks required a 20-percent level of protein for the first 6 weeks, 18 percent from 7 to 13 weeks, and 15 to 16 percent from 14 to 20 weeks.

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St. John and associates (1933) reported that the level of protein in the diet prior to the age of 10 weeks had little influence on the efficiency of protein after that age. From 10 to 24 weeks of age, as the protein in the diet was increased, it was used less efficiently. The best growth at the end of the 24-week period was obtained by feeding 17.2 percent of protein in the diet for the first 10 weeks and 13 percent from 11 to 24 weeks.

Carver and coworkers (1935) found that chicks fed at a 16-percent level of protein made superior growth at 6 and 12 weeks of age to those fed a 13-percent level. The pullets fed either the high or low levels of protein in the diet showed little difference in live weight at 24 weeks of age.

Hammond and associates (1938), using crossbred, general-purpose, male chickens, found that a diet containing 21 percent of protein, when fed ad libitum, produced the most efficient growth and that after a bird had reached approximately half its mature weight, there was little difference in efficiency between the 21- and the 15-percent protein diets.

Carver and coworkers (1935) and St. John and associates (1933) showed that the chicks fed a high-protein diet for the first 10 weeks mature slightly earlier than those on a low-protein diet, but that 4 months after egg production commenced, the average body weight of the pullets which were reared on both high- and low-protein levels in the diet were practically the same.

PROCEDURE

Nine hundred day-old, sexed, White Leghorn female chicks were used in this experiment. They were weighed and distributed among 18 pens so that each group contained 50 pullets with approximately the same mean body weight. The chicks were brooded under electrical hovers in pens 10 by 11 feet in size, and provided with a 10-foot sun porch.

A basal diet was selected similar to that recommended by this station for commercial diets. The analysis of the basal diet was as follows: Protein, 10.6 percent; calcium, 0.14; and phosphorus, 0.52. The percentages of the various ingredients in this diet were as follows:

	Percent
Ground yellow corn	43.5
Red wheat bran	18.7
Finely ground heavy oats	14.9
Ground white wheat	12.4
Dehydrated alfalfa	6.2
Powdered whey	3.7
Salt	0.6
	100.0

The composition of the four protein diets used and their average analyses are shown in tables 1 and 2. All-mash diets, supplemented only by granite grit and drinking water, were fed throughout the experiment. All the ingredients used in the experiment were analyzed previous to the mixing of the diets, and the formulas calculated to provide the desired levels of protein, 1.6 percent of calcium, and 0.8 percent of phosphorus.

The diets fed to each group and the periods of feeding are indicated in table 3.

TABLE 1.—*Composition of diets used*

Ingredient	Weights of ingredients in diets containing indicated percentages of protein			
	13	15	17	19
	Lbs.	*Lbs.*	*Lbs.*	*Lbs.*
Basal	77.50	77.50	77.50	77.50
Alaska herring fish meal	3.41	6.50	9.60	12.66
Whey powder	3.00	3.00	3.00	3.00
Yellow corn, ground	11.88	9.05	6.24	3.46
Steamed bonemeal	2.58	2.26	1.98	1.68
Oystershell flour	1.38	1.44	1.43	1.45
Concentrated cod-liver oil	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00

TABLE 2.—*Average analyses of diets used*

Nutrients	Percentage of nutrients in diets containing indicated percentages of protein			
	13	15	17	19
	Percent	*Percent*	*Percent*	*Percent*
Protein	13.20	15.10	17.10	19.20
Calcium	1.57	1.59	1.61	1.64
Phosphorus	0.83	0.79	0.81	0.86
Ash	6.70	6.57	7.22	7.39
Moisture	10.40	10.20	9.00	9.00

TABLE 3.—*Diets fed to each group and periods of feeding*

Group Nos.	Period of feeding diets containing indicated percentages of protein			
	19	17	15	13
	Weeks	*Weeks*	*Weeks*	*Weeks*
1 and 10	....	....	....	1–22
2 and 11	....	....	1–22	....
3 and 12	....	1–22	....	....
4 and 13	1–22	....	....	....
5 and 14	1–3	4–6	7–22	....
6 and 15	1–3	4–6	7–12	13–22
7 and 16	....	1–6	7–22	....
8 and 17	....	1–6	7–12	13–22
9 and 18	....	....	1–12	13–22

The chicks were individually weighed biweekly. A record was kept of the mortality and feed consumption.

RESULTS AND DISCUSSION

The growth of the chickens on the various levels of protein are shown in figure 1. At 6 weeks of age the pullets fed on the 17- and 19-percent levels had made greater growth than those fed on the 13- and 15-percent levels. At 12 weeks of age, the pullets fed on the two high levels of protein still

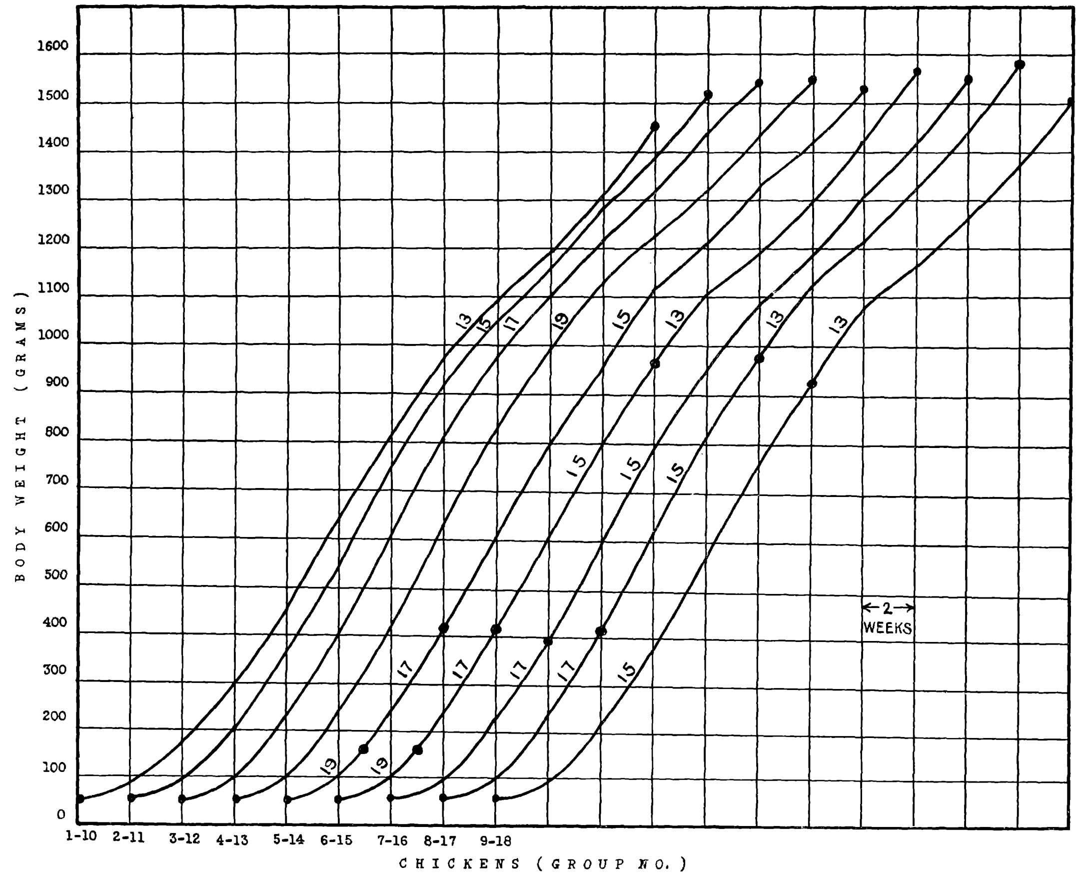

FIGURE 1.—Average body weights of groups of White Leghorn pullets fed different levels of protein from 1 to 22 weeks of age. The figures on the growth curves indicate levels of protein fed for period indicated.

TABLE 4.—*Average quantity of feed and protein consumed per bird biweekly for 22 weeks*

Weeks	Group Nos.																	
	1 and 10		2 and 11		3 and 12		4 and 13		5 and 14		6 and 15		7 and 16		8 and 17		9 and 18	
	Protein level, percent																	
	13		15		17		19		19,17,15		19,17,15,13		17,15		17,15,13		15,13	
	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein
	Gms	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*	*Gms*
1–2	183	25	191	29	221	38	213	41	202	39	211	41	200	34	203	35	200	31
3–4	294	39	345	53	358	61	377	72	374	67	378	68	357	61	372	63	351	54
5–6	497	66	557	85	590	100	610	117	596	139	617	119	596	102	601	102	570	87
7–8	692	91	726	110	772	131	779	150	780	119	779	139	805	122	809	123	761	116
9–10	853	113	846	129	893	152	907	174	887	135	911	140	905	138	914	139	865	131
11–12	907	120	885	135	879	149	931	179	923	140	918	121	945	144	955	145	897	137
13–14	1,034	136	972	148	1,026	155	1,025	197	994	151	1,046	138	1,039	158	1,078	143	1,033	136
15–16	916	121	929	141	963	164	978	188	920	140	961	127	946	144	959	127	952	126
17–18	1,076	142	1,076	164	1,068	182	1,088	209	1,155	175	1,074	142	1,057	161	1,002	132	1,066	141
19–20	1,035	137	1,056	161	1,092	186	1,112	214	1,107	168	1,117	147	1,100	167	1,090	144	1,097	145
21–22	1,145	151	1,174	178	1,187	202	1,226	235	1,162	177	1,206	159	1,182	180	1,225	162	1,130	149
Total....	8,632	1,141	8,757	1,333	9,049	1,520	9,246	1,776	9,100	1,450	9,218	1,341	9,132	1,411	9,208	1,315	8,922	1,253

showed better growth. The four groups to which different combinations of the high levels of protein were fed for the 12-week period showed little differences in body weight. At the end of 22 weeks, the groups fed the 13-percent level of protein had a lower body weight than any of the other groups. The groups fed 17 percent of protein from 1 to 6 weeks, 15 percent from 7 to 12 weeks, and 13 percent from 13 to 22 weeks showed slightly superior growth to any of the other groups.

The average quantity of feed and protein consumed per bird biweekly are presented in table 4. The feed consumption of all the groups was practically the same with the exception of the low-protein groups, which consumed considerably less feed.

efficiency of the protein in all groups as the birds became older.

In this experiment, the level of protein in the diets had little influence on the age at maturity of the pullets. The groups fed 17 percent of protein matured in 154 days, as compared with 163 days for the groups fed 13 percent of protein, or a difference of 9 days. In all the other groups fed different levels of protein in the diet, there was only a variation of 4 days in the average age at maturity.

All the mortality encountered in this experiment was caused by a slight outbreak of fowl paralysis. The quantity of protein in the diets apparently did not influence mortality in any of the groups.

TABLE 5.—*Units of feed per unit of gain and units of protein per unit of gain required biweekly for 22 weeks*

Weeks	Group Nos.																	
	1 and 10		2 and 11		3 and 12		4 and 13		5 and 14		6 and 15		7 and 16		8 and 17		9 and 18	
	Protein level, percent																	
	13		15		17		19		19,17,15		19,17,15,13		17,15		17,15,13		15,13	
	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein	Feed	Protein
1–2	3.98	0.54	3.67	0.57	3.81	0.66	3.44	0.67	3.16	0.62	3.40	0.66	3.39	0.58	3.33	0.58	3.64	0.56
3–4	3.42	.46	3.00	.46	2.75	.47	2.71	.52	2.83	.51	5.48	.51	2.81	.48	2.80	.48	3.00	.46
5–6	3.98	.53	3.50	.54	3.35	.57	3.47	.67	3.33	.78	3.39	.65	3.41	.58	3.36	.57	3.44	.53
7–8	4.33	.57	3.76	.57	3.66	.62	3.84	.74	4.06	.62	4.04	.72	4.07	.63	4.02	.61	3.90	.59
9–10	4.54	.60	4.29	.66	4.67	.80	4.63	.89	4.72	.72	4.72	.73	4.64	.71	4.57	.70	4.53	.69
11–12	5.63	.75	5.46	.84	5.11	.87	5.61	1.08	5.73	.88	5.64	.74	5.87	.89	5.46	.84	5.44	.83
13–14	5.47	.77	6.66	1.03	7.77	1.17	7.02	1.36	6.29	.97	7.11	.94	7.47	1.16	7.19	.96	6.50	.87
15–16	8.18	1.08	8.52	1.34	8.83	1.51	10.99	2.13	9.68	1.49	12.99	1.73	9.27	1.43	12.14	1.70	11.33	1.51
17–18	10.45	1.39	8.41	1.29	10.08	1.72	10.36	1.99	9.63	1.46	9.34	1.24	9.44	1.44	8.79	1.18	10.25	1.29
19–20	8.66	1.14	10.56	1.63	9.18	1.57	10.11	1.96	10.64	1.65	8.87	1.18	8.94	1.36	9.08	1.24	10.45	1.40
21–22	8.48	1.13	8.89	1.35	11.41	1.94	10.95	2.11	11.28	1.73	8.61	1.14	9.69	1.48	8.94	1.18	8.63	1.15

The groups fed 17 and 19 percent of protein in the diet had the greatest protein consumption, and the groups fed 13 percent and a combination of 15 and 13 percent had the smallest protein consumption.

The units of feed per unit of gain and the units of protein per unit of gain are given in table 5. To 16 weeks there was a trend toward a progressive increase in the units of feed required per unit of gain. At 6 weeks of age, all groups had approximately the same efficiency in the utilization of feed with the exception of the groups fed a 13-percent level of protein. At 12 weeks there was practically no difference in the efficiency of the utilization of feed among any of the groups. From 18 to 22 weeks of age, there was considerable variation in the units of feed per unit of gain owing to the requirements of the pullet for the development of the reproductive system and the rapid replacement of feathers.

The pullets in the low-protein groups made more efficient use of the protein at 6 and 12 weeks. There was a progressive trend toward decreased

SUMMARY

From 1 to 6 weeks of age the White Leghorn pullets fed 17 percent of protein in the diet maintained as satisfactory growth with about the same efficiency as groups fed the higher level.

From 7 to 12 weeks of age the pullets fed 15 percent of protein in the diet produced efficient and excellent growth.

From 13 to 22 weeks of age the groups fed 13 percent of protein showed the greatest efficiency in the utilization of the protein.

The pullets fed a 19-percent level of protein from 1 to 3 or from 1 to 6 weeks of age showed no advantage in body weight over pullets fed a 17-percent level, at the end of a 22-week growing period.

The pullets fed the higher protein levels reached sexual maturity a few days earlier than those fed the lower protein levels.

The efficiency of the feed and the protein steadily decreased with advancing age of the pullets.

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SOME OBSERVATIONS ON THE PROTEIN REQUIREMENTS OF THE LAYING FOWL

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In 1928 the writer made an estimate of the protein requirements of the laying fowl. This estimate was based on the records of selected British and Australian egg-laying trials and was published in 1929 and 1930. For maintenance, 6.5 grams of digestible protein was allowed for a 3-pound bird, with 0.9 gram of additional protein for every pound of live weight above 3 pounds. Fifteen grams of digestible protein was allowed for the production of a 2-ounce egg. This estimate was revised later as the result of data accumulated for 2 years in a selected county egg-laying trial, in which records of the feed consumed, as well as the eggs produced, per pen of birds were obtained. In this revised estimate, 1.95 grams of digestible protein was allowed for every pound of live weight for maintenance, and 10 grams of digestible protein for the production of a 2-ounce egg. Meanwhile, these estimates had received criticism on the grounds that they were too generous. Experiments in Northern Ireland had shown that high egg production could be obtained on a diet of cereal origin only, supplemented with suitable mineral mixtures. It was realized that such could be the case, since if the protein level of the diets used in the trials on which the estimates were based was too high for the egg production obtained, the estimates made from these trials must necessarily also be too high. In order to test this point, the experiments reported herein were undertaken. These experiments involved field trials under conditions of confinement, nitrogen metabolic studies, and digestibility determinations on the diets used. It is possible within the limits allowed for this paper to give only the bare essentials.

In 1936 two groups of Light Sussex hens were fed for a year under confined conditions, one group on a cereal diet alone (diet A) and the other on a similar cereal diet supplemented with 5 percent of commercial casein (diet B). The diets were balanced for mineral content, and cod-liver oil and oystershell also were given. Pellet feeding ad libitum was allowed. The essential data obtained are reported in table 1.

The main fact noted from this experiment was as follows: The added protein stimulated egg production but did not stimulate extra feed consumption.

In July 1937 a similar experiment was commenced with 48 Light Sussex pullets housed in single-battery hen cages. One group was fed diet A, consisting of a cereal mixture, and the other group received diet B, which was similar to diet A with the addition of 10 percent of meat meal. The cereal diets used in 1936 and 1937 are shown in table 2.

Table 1.—*Summary of 1936 experiment with Light Sussex hens on diets A and B*

Diet designation	Average live weight		Hen days	Weight of eggs	2-ounce eggs produced
	Pounds	*Ounces*		*Grams*	*Number*
A..........	5	3	7,924	106,111	1,871.6
B..........	5	12	7,835	139,253	2,456.3

Diet designation	Average egg production per bird per year	Digestible protein eaten	Feed consumption per bird per day
	Number	*Grams*	*Ounces*
A..............	86.7	74,469	3.82
B..............	114.0	99,318	3.79

In 1937 cod-liver oil and oystershell also were given as in the 1936 experiment. The incidence of molting was noted by observations, taken weekly, of the molting and growth of the primary wing feathers. The main data obtained are shown in table 3.

The stimulating effect on egg production is again shown, but unlike the 1936 results there is an indication that the added protein stimulated extra feed consumption.

Eighteen birds in each group survived the full year, and the data on their body weights, egg production, and feed consumption are given in table 4.

These data were subjected to statistical analysis. If x refers to the body weight, y to egg production, and z to feed consumption, the correlation coefficients which were obtained were as follows:

	Diet A	Diet B
r_{xy} =	+0.1980	−0.3386
r_{yz} =	+.7551	+.6573
r_{xz} =	+.6893	+.3660

TABLE 2.—*Cereal diets used in 1936 and 1937*

Ingredient	Proportion of ingredient in year indicated	
	1936	1937
	Percent	*Percent*
Bran	10	20
Maize meal	35	40
Weatings	20	28
Sussex ground oats	7	7
Wheat meal	25	
Medomeel (grass meal)		5
Ground chalk	2.5	
Common salt	0.5	

TABLE 3.—*Summary of 1937 experiment with Light Sussex hens on diets A and B*

Diet designation	Average live weight	Hen days	Weight of eggs	2-ounce eggs produced
	Pounds		*Grams*	*Number*
A	5.81	8,141	126,262	2,226
B	6.02	8,015	172,631	3,038

Diet designation	Average egg production per bird per year	Digestible protein eaten	Total feed consumed	Feed consumed per bird per day
	Number	*Grams*	*Pounds*	*Ounces*
A	124	70,753	2,057	4.05
B	172	117,705	2,173	4.34

These results indicate a high correlation between egg production and feed consumption, a possible positive correlation between body weight and feed consumption, and little or no correlation between body weight and egg production. On the extraction of partial correlations of two of the variables with the third eliminated, the values with which we are primarily concerned become

	Diet A	Diet B
$r_{yz.x}$ =	+0.8713	+0.8949
$r_{xz.y}$ =	+.8400	+.8031

whence it follows that there is a high positive correlation between egg production and feed consumption with the body-weight variable excluded, and a high positive correlation between the body weight and feed consumption with the egg-production variable excluded. The high correlations shown enable us to apportion the feed consumed between that used for body weight and that used for egg production, by the formula

$$Sx^2b^1 + Sxyb^2 = Sxz$$
$$Sxyb^1 + Sy^2b^2 = Syz$$

in which b^1 = coefficient in kilograms for x (body weight) and b^2 = coefficient for y (2-ounce egg),

TABLE 4.—*Data on 18 birds on diets A and B that survived the entire year*

Bird No.	Diet A			Diet B		
	Average body weight	2-ounce eggs produced	Feed consumption	Average body weight	2-ounce eggs produced	Feed consumption
	Pounds	*Number*	*Kilograms*	*Pounds*	*Number*	*Kilograms*
1	6.1	129	40.0	6.0	128	42.6
2	5.3	0	31.9	6.0	228	51.0
3	6.9	179	51.9	4.5	243	46.5
4	7.1	0	42.5	5.6	156	44.2
5	5.9	0	40.3	5.2	185	41.9
6	7.4	69	39.5	6.0	182	48.6
7	3.5	13	26.9	6.4	152	46.2
8	5.4	90	37.3	6.6	114	50.7
9	6.2	214	52.6	5.6	0	36.8
10	4.8	66	33.1	6.5	206	48.9
11	6.3	158	47.3	7.9	20	46.2
12	6.2	143	45.5	6.3	174	43.8
13	5.6	116	44.8	6.9	216	54.5
14	4.9	85	33.7	5.2	156	43.7
15	5.3	143	41.6	7.6	212	57.6
16	5.4	64	39.0	5.6	118	38.3
17	6.6	130	45.1	7.3	7	38.0
18	6.2	74	40.3	5.8	238	50.1

TABLE 5.—*Relationship between total-feed and digestible-protein requirements for body maintenance and egg production*

Designation of diet	Daily feed requirement per pound of live weight		Feed requirement per 2-ounce egg	
	Total feed	Digestible protein	Total feed	Digestible protein
	Grams	*Grams*	*Grams*	*Grams*
A	14.75	1.12	86.94	6.58
B	15.46	1.81	73.41	8.61

whence it can be shown that the values for b^1 and b^2 in kilograms are as follows:

	b^1	b^2
Diet A	5.369	0.08694
Diet B	5.643	.07341

These values may be reduced to those shown in table 5.

The metabolic trials carried out at the same time as the field trials enable us to check the validity of these results. The main data of the metabolic trials are summarized in table 6.

By allowing 6.58 grams per 2-ounce egg in the case of the cereal diet and 8.61 grams per 2-ounce egg in the case of the cereal diet plus protein, it will be noted that the figures for maintenance requirement are in close agreement for the cereal diet and in reasonable agreement for the cereal plus protein diet. Considerable variation occurs in individual capacity to convert feed protein into egg protein. This individual variation is undoubtedly linked up with the metabolic efficiency of the endocrine systems, etc., and with variable appetite among individuals, and it is suggested that egg-laying trials should be redesigned so that individuals of high efficiency for conversion of feed material to egg material may be detected.

TABLE 6.—*Results obtained in metabolic trials with the use of diets A and B*

Diet A—cereal diet alone

Duration of experiment (days)	Average body weight	Digestible proteins— Consumed	Stored (+) or lost (−)	Used for egg production[1]	Used for maintenance	Used for maintenance per pound of live weight
	Pounds	*Grams*	*Grams*	*Grams*	*Grams*	
85	4.90	766.7	−10.0	253.1	523.6	1.26
85	5.13	811.8	+55.8	56.6	699.4	1.60
80	5.67	1,021.0	+117.9	304.7	598.4	1.32
80	6.28	751.1	+71.7	176.0	503.4	1.00
80	4.86	672.3	+187.2	62.6	422.5	1.09
80	5.33	722.6	+39.6	301.9	381.1	.89

Diet B—cereal diet + protein

Duration of experiment (days)	Average body weight	Consumed	Stored (+) or lost (−)	Used for egg production[1]	Used for maintenance	Used for maintenance per pound of live weight
85	5.13	1,143.7	+78.3	328.5	736.9	1.68
85	4.27	918.7	−3.8	314.0	608.5	1.68
80	4.76	759.1	+5.4	249.7	504.0	1.30
80	5.60	809.0	+30.3	276.1	502.6	1.12
80	5.93	1,173.4	+97.3	399.8	676.3	1.42
80	6.12	1,406.5	+241.9	173.7	990.9	2.02

[1] For diet A, egg production × 6.58; for diet B, egg production × 8.61.

ADDENDUM

In the 1936-1937 experiments, in which the conclusion was reached that the digestible protein requirements for maintenance per pound of live weight were apparently 1.1 g and the requirements per 2-ounce egg 6.6 g, the controlling factor was the appetite of the birds. The possibility therefore existed that more protein was consumed than was actually required for maintenance and egg production. Ackerson, Blish, and Mussehl had shown that the endogenous loss of nitrogen by nonmolting Rhode Island Reds was 0.144 g per kilogram of body weight, or 0.409 g of protein per pound. The protein in a 2-ounce egg weighs approximately 6.25 g. The efficiency of conversion of digestible protein for maintenance and for egg protein would, on this basis, be 37.2 and 94.7 percent, respectively, according to the estimates given above. On theoretical considerations, it would not be expected that the efficiency of conversion for maintenance would be less than the efficiency of conversion for the production of egg protein. The probability therefore existed that under the conditions of the experiment the birds consumed more protein during the nonlaying periods than was actually required for maintenance. Consequently, there was a reserve which would be available during the laying periods. The effect of this condition would be that the efficiency of conversion of protein for maintenance would be less than was the case, and the efficiency of conversion of feed protein to egg protein would be greater. To test this possibility, two Light Sussex pullets were given a ration of 75 g of a low-protein diet, and daily nitrogen balances were obtained. The diet as given resulted in a slight positive nitrogen balance. After the birds had become accustomed to this ration and were giving steady balances of nitrogen, an additional 15 g of a high-protein diet were given daily. On this latter diet satisfactory egg production resulted. The main data obtained are shown in table 7.

TABLE 7.—*Data obtained on two birds fed a low-protein diet followed by a high-protein diet*

Bird 1

Period	Days	Average body weight	Total nitrogen fed	Digestible nitrogen	Excretory nitrogen	Nitrogen balance
	Number	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Nonlaying	30	2,561	22.80	20.13	18.32	+4.58
Laying	46	2,534	53.37	49.17	40.46	+12.91

Bird 2

Period	Days	Average body weight	Total nitrogen fed	Digestible nitrogen	Excretory nitrogen	Nitrogen balance
Nonlaying	20	2,308	15.20	13.42	13.13	+2.07
Laying	28	2,413	43.37	40.94	30.56	+12.81

The digestible-nitrogen figures were obtained by means of pepsin digests, since the metabolic nitrogen of alimentary origin depressed the apparent digestibility obtained by the Katayama method.

During the nonlaying periods, the nitrogen-maintenance requirement based on the above data, was 0.202 g per kilogram of body weight for bird 1 and 0.245 g per kilogram for bird 2. When these values were substituted for maintenance in the laying periods, 25.62 g of digestible nitrogen were available for egg production in the case of bird 1 and 24.39 g in the case of bird 2. Bird 1 laid 708.7 g of egg, and bird 2 laid 721.0 g, whence it follows that for the production of a 2-ounce egg bird 1 utilized 2.05 g of digestible nitrogen, or 12.8 g of digestible protein, and bird 2 utilized

1.92 g of digestible nitrogen, or 12.0 g of digestible protein. In nitrogen metabolic trials with low-protein diets carried out on Light Sussex pullets by my colleague Dr. E. M. Cruickshank, negative balances were obtained on a ration containing 0.129 g of nitrogen and 0.132 g of nitrogen per kilogram of body weight, and a slightly positive and a slightly negative balance with two birds on a daily ration containing 0.206 g of digestible nitrogen and 0.210 g of digestible nitrogen per kilogram of body weight. These figures show reasonable agreement with the maintenance-requirement figures of 0.202 g and 0.245 g obtained for birds 1 and 2, respectively. It is therefore suggested that for the purpose of feeding standards 0.22 g of digestible nitrogen per kilogram, or 0.625 g of digestible protein per pound, of body weight should be adopted, and that for the production of a 2-ounce egg 12.5 g of digestible protein is a reasonable figure.

With these figures, the efficiency of conversion of digestible protein in this experiment is approximately 65 percent for maintenance and 50 percent for egg-protein production, results which are more in accordance with theoretical expectation.

SUMMARY

Field and metabolic trials carried out with Light Sussex hens and pullets led to the following conclusions:

A high positive correlation exists between feed consumption and egg production.

A high positive correlation exists between live weight and feed consumption for maintenance.

Protein of animal origin added to a cereal ration leads to an increase in egg production, but the conversion of feed protein to egg protein may be less efficient. Nevertheless, the increased monetary return from the extra egg production may justify such a practice from the commercial point of view.

In the case of the Light Sussex breed, it appears that the daily digestible protein requirement for maintenance per pound of live weight is 0.625 g, and for the production of a 2-ounce egg, 12.5 g.

VERGLEICH TIERISCHER EIWEISSFUTTERMITTEL IN DER LEGEHENNENFÜTTERUNG

Von Edwin Lauprecht, *Aus dem Institut für Tierzucht der Universität Göttingen, Deutschland*

In der Geflügelhaltung des Versuchsgutes Friedland der Universität Göttingen wurden in den Jahren 1936 bis 1938 Fütterungsversuche mit einigen in Deutschland hergestellten Eiweißfuttermitteln an weißen Leghornhennen durchgeführt. Derartige Futtermittel sind für die planmäßige Geflügelfütterung von großer Bedeutung, weil sie den Geflügelhalter unabhängig von den wechselnden Bedingungen des Außenhandels machen.

In den Versuchen wurden in Anschluß an frühere Untersuchungen folgende Futtermittel einzeln oder in Mischungen geprüft: Fischmehl (entfettet), Walfleischmehl, Garnelen (getrocknet), Seidenspinnerpuppen (nicht entfettet), Seidenspinnerpuppen (entfettet), Milchalbumin, ferner zu Vergleichszwecken Trockenhefe, und eine käufliche Hefemischung (Brauereiabfälle, bestehend aus Trockenhefe, Faßgeläger und Trub zu gleichen Teilen).

Im folgenden werden die Ergebnisse von vier praktischen Versuchen mit tierischen Eiweißfuttermitteln kurz dargestellt und anschließend gemeinsam verglichen.

1.—FISCHMEHL, WALFLEISCHMEHL, GARNELENSCHROT, ENTFETTETE SEIDENSPINNERPUPPEN

In diesem an vier Gruppen von je 37 Hennen in der Zeit vom 1. November 1937 bis 15. August 1938 durchgeführten Vergleich wurde folgende Trokkenmischung in Selbstfütterern verabfolgt: 20 Teile Weizenkleie, 25 Teile Maisschrot, 25 Teile Gerstenschrot, 5 Teile Luzernemehl, 5 Teile Kalk, 20 Teile eiweißreiches Futter. Nach 6 Monaten wurde das Maisschrot durch Futterweizenschrot ersetzt.

Als eiweißreicher Anteil der Mischung diente im ersten Abschnitt bei Gruppe A und B Garnelenschrot, bei Gruppe C und D Fischmehl. Im zweiten Abschnitt wurde die Gruppe B auf Walfleischmehl und die Gruppe C auf entfettete Seidenspinnerpuppen umgestellt.

Gruppe	eiweißreiches Futter	Eier Anzahl	Eigewicht insges. g	Eigewicht mittel g	Futter für 100 g Eier g
Versuchsabschnitt I					
A	Garnelen	91,1	5071	55,6	379
B	Garnelen	84,4	4731	55,9	396
C	Fischmehl	115,3	6399	55,4	302
D	Fischmehl	117,6	6368	54,1	312
Versuchsabschnitt II					
A	Garnelen	28,6	1650	57,7	514
B	Walfleischmehl	23,1	1325	57,5	577
C	Seidenspinnerpuppen, entfettet	21,5	1218	55,6	640
D	Fischmehl	41,7	2301	55,1	370

Es ergibt sich im ersten Abschnitt in der absoluten Legeleistung und in der Futterverwertung eine starke Überlegenheit der beiden Fischmehlgruppen über die Garnelenschrotgruppen. Im zweiten Abschnitt macht sich der Übergang von Garnelenschrot auf Walfleischmehl bei der Leistung im Vergleich zur Gruppe A nicht so sehr bemerkbar; dagegen wirkt sich der Wechsel von Fischmehl auf entfettete Seidenspinnerpuppen wesentlich ungünstiger aus. Man kann diese Erscheinung bei der Länge des Abschnittes auch nicht allein auf die Futterumstellung zurückführen.

2.—FISCHMEHL, GETROCKNETE SEIDENSPINNERPUPPEN (NICHT ENTFETTET)

Dieser Vergleich fand in der Zeit vom 1. November 1936 bis 31. August 1937 statt in Gruppen von je 15 Hennen. In diesem Fall wurde als Grundfutter eine Trockenmischung gegeben, bestehend aus 30 Teilen Weizenschrot, 30 Teilen Gerstenschot, 10 Teilen Kartoffelflocken, 5 Teilen Luzernemehl, 5 Teilen Kalk. Als Ergänzung kamen hinzu in der Gruppe E 20 Teile Fischmehl und in der Gruppe F 20 Teile getrocknete nicht entfettete Seidenspinnerpuppen. Der Versuch wurde nach diesem Plane drei Monate durchgeführt. Dann erfolgte im zweiten Abschnitt in der Gruppe F ein Ersatz von 10 Teilen Seidenspinnerpuppen durch 10 Teile Fischmehl.

Versuchsabschnitt I. 1.11.-31.1

Gruppe	eiweißreiches Futter	Eier Anzahl	Eigewicht insges. g	Eigewicht mittel g	Futter für 100 g Eier
E	Fischmehl	23,9	1187	49,7	660
F	nicht entfett. Seidenspin. Puppen	9,9	475	47,9	1438
	Versuchsabschnitt II. 1.2.-31.8				
E	Fischmehl	114,5	6231	54,4	357
F	10 T. Fischmehl. 10 T. nicht entf. Seidenspinnerpuppen	136,7	7522	55,0	300

Da die Tiere erst im Dezember mit Legen begannen, war im ersten Abschnitt die mittlere Leistung verhältnismäßig niedrig und die Futterverwertung zur Eiererzeugung entsprechend ungünstig. Die nicht entfetteten Seidenspinnerpuppen wurden sehr ungern gefressen, was wahrscheinlich zum Teil auf die hohen in ihnen enthaltenen Fettmengen zurückzuführen ist. Ausserdem hatten die Hennen bei diesem Futter ein sehr schlechtes Aussehen und versagten in der Legeleistung vollständig, obwohl sie aus derselben Brut von gleichen Müttern stammten. Ungünstige Wirkungen von nichtentfetteten Seidenspinnerpuppen stellten auch Mangold und Fangauf fest.

Es wurde daher nach drei Monaten bei dieser Gruppe die Hälfte der Puppen durch Fischmehl ersetzt. Von diesem Zeitpunkt an stieg die Leistung der Gruppe F sofort sehr stark und blieb bis zum Ende des Versuches ständig über derjenigen der Fischmehlvergleichsgruppe. Daß Seidenspinnerpuppen in Verbindung mit anderen tierischen Eiweißfuttermitteln brauchbar sind, geht auch aus Beobachtungen von Vetter hervor.

3.—FISCHMEHL, HEFE

Dieser Versuch lief in der Zeit vom 1. November 1936 bis 31. August 1937 in Gruppen von je 15 Junghennen (Schlupf 4. Juni). Allen Gruppen stand folgende Trockenmischung in Selbstfütterern ständig zur Verfügung: 30 Teile Weizenschrot, 30 Teile Gerstenschrot, 10 Teile Kartoffelflocken, 5 Teile Luzernemehl, 5 Teile Kalk, 20 Teile eiweissreiches Futter bestehend in Gruppe G aus Fischmehl, in Gruppe H zu gleichen Teilen aus Fischmehl und Trockenhefe sowie in Gruppe I zu gleichen Teilen aus Fischmehl und Hefemischung. Vorübergehend bekamen alle drei Gruppen ausserdem etwas gekochte Kartoffeln.

Gruppe	eiweißreiches Futter	Eier Anzahl	Eigewicht insges. g	Eigewicht mittel g	Futter für 100 g Eier g
G	Fischmehl	138,4	7419	53,5	410
H	Fischmehl u. Trockenhefe	144,5	7897	54,6	372
J	Fischmehl u. Hefemischung	149,5	8359	55,8	343

In diesem Versuch sollte die Wirkung eines Ersatzes der Hälfte des Fischmehls durch Hefefuttermittel geprüft werden. Dieser erfolgte in der Gruppe H durch gewöhnliche Trockenhefe und in der Gruppe J durch eine Hefemischung, welche aus verschiedenen Brauereiabfällen bestand und zwar zu gleichen Teilen aus Trockenhefe, Faßgeläger und Trub. Die Verbindung von Gaben dieser Hefefuttermittel mit Fischmehl wirkte sich auf die Höhe der Legeleistung und auf die Futterverwertung nicht ungünstig aus. Der absolute Gesamtfutterverzehr war in allen Gruppen gleich.

Es sei erwähnt, daß zur Kontrolle der Wirkung des Fischmehls dasselbe vom 1. bis 15. Juli in allen Gruppen ohne Ersatz aus den Mischungen fortgelassen wurde. In dieser Zeit ging in den drei Gruppen die Legetätigkeit sehr stark zurück, während sie nach Wiedergabe des Fischmehls sofort wieder zunahm.

4.—FISCHMEHL, ENTFETTETE SEIDENSPINNERPUPPEN, MILCHALBUMIN, HEFEMISCHUNG

Diese Untersuchung wurde in der Zeit vom 1. Dezember 1936 bis 31. August 1937 an zwei Gruppen mit je 37 Hennen durchgeführt. Sie sollte einerseits die Brauchbarkeit von Milchalbumin in Verbindung mit anderen Futtermitteln klarstellen und andererseits die Frage des häufigeren

Eiweißfutterwechsels auf die Höhe der Leistung nochmals prüfen.

Versuchs-Abschnitt	Gruppe	eiweißreiches Futter	Eier Anzahl	Eigewicht insg., g	Eigewicht mittel, g	Futter für 100 g Eier Misch., g	Futter für 100 g Eier Körner, g
I.1.12-31.12	K.	15 Fischm. 10 Milchalb.	11,5	599	51,8	230	259
	L.		13,9	700	50,1	120	268
II.1.1.-28.2	K.	25 Milchalb.	31,6	1704	53,8	187	173
	L.	15 Fischm. 10 Milchalb.	33,7	1805	53,4	172	164
III.1.3-31.3	K.	12,5 Milchalb. 12,5 Seidensp.	14,8	818	55,2	184	189
	L.	15 Fischm. 10 Milchalb.	19,2	1052	54,9	147	147
IV.1.4-31.5	K.	15 Fischm. 10 Milchalb.	36,4	2045	56,2	155	149
	L.		40,1	2238	55,8	165	136
V.1.6-30.6	K.	12,5 Fischm. 12,5 Hefem.	16,1	880	54,6	205	170
	L.	15 Fischm. 10 Milchalb.	17,1	929	54,2	205	161
VI.1.7-15.7	K.	25 Hefem.	4,9	269	54,4	287	279
	L.		4,5	239	53,0	314	314
VII.16.7-31.7	K.	12,5 Fischm. 12,5 Hefem.	2,9	158	55,4	327	506
	L.		1,8	101	55,3	497	792
VIII.1.8-31.8	K.	25 Milchalb.	6,5	367	56,9	351	422
	L.	25 Fischm.	15,7	888	56,6	149	175

Im 1. und 4. Abschnitt, in dem beide Gruppen Fischmehl und Milchalbumin erhielten, zeigte sich eine geringe Überlegenheit der Leistung in der Vergleichsgruppe L. über diejenige in der Gruppe K. Dieses Bild änderte sich nicht bei Ersatz des Fischmehlanteils durch Milchalbumin im Abschnitt II und durch entfettete Seidenspinnerpuppen im Abschnitt III. Auch gegen Hefemischung ließ sich Milchalbumin bei gleichzeitiger Gabe von Fischmehl ohne Nachteil austauschen.

Zur Kontrolle der Wirkung des tierischen Eiweiß wurde in der ersten Augusthälfte (Abschnitt VI) nur Hefemischung als Eiweißfutteranteil im Selbstfütterer gegeben. Diese Umstellung brachte einen so starken Rückgang der Leistung, daß die darauf folgende 14 tägige bewährte Fischmehlhefefütterung denselben nicht aufhalten konnte. (Abschnitt VII). Erst die volle Gabe Fischmehl oder Milchalbumin brachte wieder einen Anstieg der Legeleistung, welcher jedoch beim Fischmehl besser war als beim Milchalbumin.

Dieser Versuch hat entsprechend den früheren Ergebnissen von Fangauf und von uns in den Abschnitten I und V erneut gezeigt, daß von einem Futterwechsel bei sachgemäßer Futterzusammenstellung Nachteile für die Gesamtleistung nicht zu befürchten sind.

ZUSAMMENFASSUNG

Die angeführten Versuche wurden in einem praktischen Betriebe durchgeführt, um den Geflügelhaltern die Möglichkeit zu geben, sich mit der Wirkung von einigen Handelsfuttermitteln tierischer Herkunft auf die Legeleistung vertraut zu machen. Insbesondere sollte gezeigt werden, wie durch zweckmäßige Zusammenstellung derartiger Eiweißfuttermittel die Eierproduktion erhöht werden kann.

Im einzelnen ergab sich in den Versuchen, daß bei dem Vergleich einzelner Futtermittel das Fischmehl den getrockneten Garnelen, den Seidenspinnerpuppen (entfettet und nicht entfettet) und dem Milchalbumin in seiner günstigen Wirkung auf die Legeleistung überlegen ist. In gleicher Beziehung übertraf das Walfleischmehl die Seidenspinnerpuppen (entfettet).

Wenn aber Seidenspinnerpuppen und Milchalbumin, welche dem Fischmehl allein nicht gleichwertig waren, teilweise durch Fischmehl ersetzt wurden, ließ sich der gleiche Erfolg erzielen, wie bei alleiniger Fischmehlgabe.

Die zum Vergleich mit den tierischen Eiweißfuttermitteln herangezogene Hefemischung beeinflußte, als alleiniges Eiweißfutter verabfolgt, die Legeleistung sehr nachteilig. Bemerkenswert ist, daß die gemeinsame Verfütterung von Fischmehl und Hefefuttermitteln sehr günstige Ergebnisse zeitigte.

Die Lebendgewichtsentwicklung, die Gesundheit und der Ausfall von Tieren waren in allen Versuchen normal und ohne Einfluß auf die Beurteilung der Futtermittel.

Bei den Eiern wurden keine Qualitätsmängel beobachtet.

SUMMARY

The described experiments were carried out in practical enterprises in order to enable poultry breeders to familiarize themselves with the effect of a few commercial foodstuffs of animal origin upon laying efficiency. It was particularly intended to show how egg production may be increased through the proper composition and preparation of such protein feeds.

A comparison of the various foodstuffs during the experiments showed that fish meal is superior to dried shrimp, cocoons (defatted and not) and milk albumin with respect to its favorable effect upon laying efficiency. In this respect meat meal was also superior to cocoons (free from fat).

However, if cocoons and milk albumin, which in themselves are not equal to fish meal, are partly replaced by fish meal, the same results may be obtained as with the feeding of fish meal alone.

The yeast mixture used for comparison with the animal protein foodstuffs has a very unfavorable effect upon laying efficiency if fed as the only protein feed. It is noteworthy that the feeding of fish meal and yeast feeds together leads to favorable results.

The development of live weight, health, and losses of animals were normal during all experiments and did not in any way influence the judgment on the foodstuffs used.

No deficiencies in the quality of the eggs could be observed.

INVESTIGATION OF IMPROVED POULTRY FEEDING IN BULGARIA

By IVAN J. TABAKOFF, *Director of Central Poultry Experiment Station, Sofia, Bulgaria*

The feeding of poultry in the village agricultural households, which supply all the eggs and birds for the Bulgarian export market, is still primitive, scanty, and unbalanced. Especially bad is the feeding of poultry in winter, as a result of which the winter egg production is very low. In order to improve the feeding of poultry in the village households, the Central Poultry Experiment Station near Sofia undertook a number of experiments to determine the value of several local feeds rich in protein, these feeds being meat meal, bone meal, and sunflower-oil cake.

The results of the 2 years' experiment, from November 1, 1935, to October 31, 1937, are given in this paper. The objects of this experiment were the following:

1. To determine the difference in egg production and hatchability, body condition, and other qualities of the birds when they received, in addition to the other feeds (*a*) meat meal, bone meal, and sunflower-oil cake; (*b*) only meat meal and bone meal; (*c*) only bone meal and sunflower-oil cake and (*d*) none of the above-mentioned feeds which are rich in protein.
2. To verify the recommended methods for improving poultry feeding in Bulgaria.
3. To determine the economic results of the use of these feeds in poultry feeding.

The experiment was carried out with four groups of 25 pullets each, 12 being White Leghorns, 5 Black Minorcas, 4 Rhode Island Reds, and 4 Black Shumens (a local breed). Each pullet of the first group had a sister pullet in the other three groups; therefore, the groups were identical as to race, origin, and age, and of similar live weight.

The first group received a dry-mash mixture containing 15 percent of meat meal, 7 percent of bone meal, and 15 percent of sunflower-oil cake; the second, a mixture containing 20 percent of meat meal and 7 percent of bone meal; the third, a mixture containing 7 percent of bone meal and 20 percent of sunflower-oil cake; and the fourth, a mixture without any of these feeds rich in protein. The first group was given a grain mixture of 50 percent of yellow corn and 50 percent of wheat, and the remaining three groups received a grain mixture of 60 percent of yellow corn and 40 percent of barley. Each group received at noon a wet-mash mixture containing green feed cut into small pieces; in the spring and summer green alfalfa was used and in the autumn and winter, cabbage and mangel beets. The method of feeding and the quantity of grain, wet mash, and green feeds were the same for the four groups. Table 1 gives data on the average ration per bird for the 2-year period.

TABLE 1.—*Data on ration per bird in the four groups*
(Average for 2 years)

Group No.	Digestible protein		Total digestible nutrients	Nutritive ratio
	Total	Animal origin		
	Percent	*Percent*	*Percent*	
1	15.2	4.7	73	1:3.8
2	14.3	5.9	74.2	4.2
3	13.2	1	71.6	4.4
4	9.8	0	73.8	6.5

The first three groups were raised indoors from the beginning of November to the end of March, but the fourth was raised indoors only during very cold weather. The ration and method of feeding the birds of the last group were the same as those of the birds kept by the village households.

Records on each group were kept for egg production, egg weight, live weight, mortality, molting, hatchability, and quantity of feed consumed. The egg production was determined by control nests and the egg weight by weighing separately each egg produced. The average annual egg production was calculated on the basis of all egg-laying days, and the average egg weight on the basis of the total weight of all eggs produced divided by their total number. For determining the live weight, the birds were weighed separately at the beginning of each month. Table 2 shows the results on egg production and the proportion of laying pullets in the four groups during the 2-year period. The average live weights and mortality of the four groups are shown in table 3.

With regard to the molting of the four groups there was no marked difference due to the methods of feeding. In all the groups this process began at the close of July or the beginning of August and ended during February. The hatchability of fertile eggs for the four groups is shown in table 4. Considering the almost equal hatchability of the separate groups during the first year, we may decide that the different rations did not have any influence in this respect.

From the data given it is evident that the differences in the egg production, live weight, and mortality are in favor of the first two groups. However, to determine the significance of these differences, the costs must be obtained. We must determine for each group separately the relation between the feed consumption and egg production, the feed cost for each egg produced, and the total income per bird or per group. These data are shown in table 5. The first group, which was fed most regularly and rationally, gave the biggest net income. The second group, in spite of the fact that its egg production was higher than that of the third and fourth groups, returned only a little more than half as much net income per bird and per group as did the last two groups. This result is due to the great difference in the price of the mash used for these three groups, since the prices of the other feeds were the same. Table 6 shows the cost of the mash for the four groups.

The price of the meat meal was 9 leva per kilogram during the 2 years and 8.5 leva during the first laying year; of the bone meal, 6 and 5 leva, respectively; and of the sunflower-oil cake, 1.50 leva per kilogram during the 2 years.

From the data obtained from this 2-year experiment we may conclude the following:

The difference in the average biennial egg production between the first and fourth groups was the greatest—76.8 eggs, or 23.3 percent. Between the second and fourth it was smaller—34 eggs, or 11.9 percent—and between the third and fourth groups it was the smallest (18.5, or 6.8 percent). The same statement applies to live weight and mortality of the birds but in molting, and in the hatchability no marked difference was observed.

Adding meat and bone meal and substituting sunflower-oil cake for a part of the meat meal (in our case 1 part of the meat meal was substituted for 3 parts of sunflower-oil cake) has proved favorable for egg production, growth and health of the birds, and has given the largest net income.

Adding sunflower-oil cake and bone meal to

TABLE 2.—*Egg production and proportion of laying pullets for the four groups during the 2-year period*

Group No.	Egg production per bird		Egg weight		Proportion of laying pullets	
	Average for 2 years	First egg-laying year	Average for 2 years	First egg-laying year	First year	Second year
	Number	*Number*	*Grams*	*Grams*	*Percent*	*Percent*
1	329.5	183.7	59.3	57.7	50.2	38.4
2	286.7	152.3	57.6	56.3	41.6	35.1
3	271.2	141.9	59.7	58.4	38.9	34.5
4	252.6	129.4	56.5	54.7	35.4	32.6

TABLE 3.—*Live weights and mortality of the four groups during the 2-year period*

Group No.	Live weight per bird		Extent of mortality	
	Average for 2 years	First egg-laying year	Average for 2 years	First egg-laying year
	Kilograms	*Kilograms*	*Percent*	*Percent*
1	2.03	2.02	16	12
2	1.95	1.99	28	16
3	1.85	1.84	32	20
4	1.70	1.67	44	32

TABLE 4.—*Hatchability of fertile eggs of the four groups*

Group No.	Average for 2 years	First egg-laying year
	Percent	*Percent*
1	72.7	73.0
2	66.8	70.1
3	76.2	76.7
4	75.1	73.4

TABLE 5.—*Relation between feed consumption and egg production, feed cost of each egg produced, and net income from the eggs for the four groups of birds*

Group No.	Eggs produced per kilogram of total digestible nutrients		Feed cost[1] for each egg produced		Net income[2] from eggs per— Group		Net income[2] from eggs per— Bird	
	Average for 2 years	First egg-laying year	Average for 2 years	First egg-laying year	Average for 2 years	First laying year	Average for 2 years	First laying year
	Number	*Number*	*Leva*	*Leva*	*Leva*	*Leva*	*Leva*	*Leva*
1	5.9	6.6	0.82	0.71	2,566	2,115	117.9	86.9
2	4.0	5.4	.98	.87	1,116	1,138	58.5	47.0
3	4.9	5.2	.77	.70	2,068	1,542	109.8	67.8
4	4.4	4.5	.74	.70	1,820	1,246	108.9	61.6

[1] 100 leva = $1.
[2] Total income less cost of feed.

TABLE 6.—*Cost of mash for the four groups of birds*

Group No.	Cost per kilogram of— Mash		Cost per kilogram of— Digestible nutrients	
	Average for 2 years	First egg-laying year	Average for 2 years	First egg-laying year
	Leva	*Leva*	*Leva*	*Leva*
1	3.39	3.27	4.89	4.66
2	3.74	3.62	4.94	4.69
3	2.33	2.24	3.81	3.62
4	2.23	2.16	3.24	3.12

the diet of the birds has proved to be more profitable than adding meat and bone meal.

A diet containing meat and bone meal is less profitable even than a diet containing no meat and bone meal or sunflower-oil cake.

On the basis of the results of this biennial experiment we recommend, for improving the feeding of poultry on Bulgarian farms, first of all the use of sunflower-oil cake, which must comprise 25 percent of the daily feed of layers, especially during the winter months. Until the establishment of greater and cheaper local production of meat and bone meal, their use for poultry feeding will be limited only to the State and well-organized private farms.

SUMMARY

To improve poultry feeding on Bulgarian farms, the Central Poultry Experiment Station near Sofia carried on a 2-year experiment for the purpose of testing certain kinds of high-protein feeds of a local origin.

Four groups of 25 pullets each were used. The groups were uniform as to race, breeding, date of hatching, and live weight of the birds. The first group was given a mixture of 15 percent meat meal, 7 percent bone meal, and 15 percent sunflower-oil cake; the second group received a mixture of 20 percent meat meal and 7 percent bone meal; the third group was given a mixture of 7 percent bone meal and 20 percent sunflower-oil cake; and the fourth, a mixture lacking the above-mentioned high-protein feeds. In addition the first group received a mixture of 50 percent of yellow corn and 50 percent of wheat, whereas the other three were given a mixture of 60 percent of yellow corn and 40 percent of barley. In feeds given and type of husbandry, the fourth group resembled those on the village farms. Each group was controlled for egg-production and egg weight, live weight, mortality, molting, hatching, and quantity of feed consumed. The following results were obtained:

Group 1 had the highest egg production, next to the highest average egg weight, and the highest average live weight of the birds at the end of the experiment; group 4 was lowest in these respects. Groups 2 and 3 were intermediate except for the average egg weight in the case of group 3, which was slightly higher than group 1 in this respect.

The mortality of the first group was 16 percent; of the second, 28 percent; of the third, 32 percent; and of the fourth, 44 percent. In the first group, about 73 percent of fertile eggs hatched; in the second, 67 percent; in the third, 76 percent; and in the fourth, 75 percent.

When only expenses for feed are taken into consideration, each egg produced cost 0.82 leva for the first group, 0.98 leva for the second, 0.77 leva for the third, and 0.74 leva for the fourth group. The differences between the income obtained from the eggs and the expenses for feed per bird were, on the average, about 118 leva for the first group, 58 leva for the second, 110 for the third, and 109 for the fourth. In spite of the fact that the second group had a higher egg production than the third and fourth groups, it returned only half as much net income per bird. This is due to the great difference in the price of the feed for this group. A kilo of the mash mixture given to the first group cost 3.39 leva; to the second, 3.74 leva; to the third, 2.33 leva, and to the fourth, 2.23 leva. The price of 1 kilo of meat meal is about 9 leva, and of sunflower-oil cake, 1.50 leva.

From the results obtained in this survey, we recommend the use of sunflower-oil cake in the feeding of poultry to the extent of 25 percent of the daily feed of layers, especially during winter.

POTATOES AND SKIM MILK AS FEED FOR LAYING HENS

By IVAR FINNE, *Hvalstad, Norway*

THE PROBLEM

The greater part of Norway lies between 60° and 70° N., and as the conditions for cultivation of grain and other kinds of concentrated feedstuffs are therefore unfavorable, it has been found necessary to investigate the extent to which nonconcentrated feeding materials can be used for laying hens.

The principal requirements of a feed for hens are that it must have sufficient concentration and be digestible, but at the same time it must have a favorable dietetic effect and yield eggs of good quality.

Owing to the demand for concentration and digestibility, it is evident that such materials as grain and meal, with their high energy-giving qualities and relatively small content of fibers, are the most suitable for feeding hens. But other feedstuffs may possess a relatively high concentration and contain energy in easily accessible form. Examples of such feeds are potatoes and milk. As regards potatoes, which are grown in practically all parts of the country, there have often been great differences of opinion as to their suitability as feed for fowl. The objection most generally advanced is that the hens become heavy and torpid with a tendency to greater deposition of fat than normal and to reduced laying capacity. As to milk, it has long been regarded by poultry keepers as an excellent feed for both younger and older fowl, but the quantities employed have been based on practical experience, without exact data respecting the effects of milk on the laying capacity and state of health of the poultry.

The purpose of the present experiments, which were carried out by the author and T. B. Hesthamar, B.Sc.Agr., has been to investigate to what extent milk and potatoes can be used for laying hens and how these feedstuffs, employed in different quantities, act on the laying powers of the hens, the quality of the eggs—especially of eggs for the table (breakfast eggs)—as well as on the health and development of the fowl. Owing to limited space for this report, a detailed account is given only of the experiments with milk and merely a summary of the results attained in the experiments with potatoes.

EXPERIMENTAL PROCEDURE

Experimental groups used

The experiments were carried out at the State Training School for Teachers to Smallholders (Statens Smaabrukslærerskole). As the Norwegian poultry keepers use both the lighter and the heavier breeds, it was desirable to investigate the effects of the feedstuffs in question on both types of fowl. As the experiments were practically the same for the light and medium-heavy breeds, the description is mainly confined to results attained with the light breed. Information regarding each experiment is given in table 1.

TABLE 1.—*Details regarding experimental set-up*

Experiment No.	Feed given	Breed used	Fowl	Duration of experiment
			Number	*Days*
1........	Boiled potatoes....	White Leghorn....	240	270
2........	........do..........	Light Sussex.......	111	270
3........	Skim milk.........	Plymouth Rock...	210	310
4........	........do..........	White Leghorn....	205	300

All four experiments were conducted as group experiments. As the yield of eggs is highest in the first year of laying and as hens of that age must be assumed to react more readily to a varied diet, 1-year-old fowl were selected for all the experiments. The birds were divided into groups according to live weight and time of beginning to lay. As far as possible, closely related birds were distributed equally among the different groups. The hens were weighed at the beginning of the experiment, as well as once every month and at the conclusion of the experiment. Before the commencement of the experiments each group had a preparatory period of at least 8 days. Sick and broody fowls were at once removed from the groups. All the feed consumed therefore is calculated on the number of actual feeding days.

Evaluation of the test feeds

All the groups received a fixed ration of grain, mixed in the proportions of 40 percent of wheat, 30 percent of oats, and 30 percent of crushed maize. One kilogram of the mixture is equal to 980 grams of feed units[1] with 75 g of digestible protein.

The content of solid matter in the potatoes used was 25 percent, 4 kg thus being reckoned as equal to 1 Scandinavian feed unit.

Six kilograms of skim milk is reckoned to equal 1 feed unit. The content of feed unit and protein in the mixed grain was calculated on the basis of chemical analyses.

Additions of succulent feed, such as turnips in winter and grass in summer, are not taken into account in judging the results. Otherwise, all feed consumed and the effects thereof, the number and weight of the eggs, etc., were carefully controlled during the whole period of the experiment.

Investigation of the properties of eggs for table use

The following properties were investigated: Visibility and mobility of yolk, color and consistency of white, as well as size of air space. These characteristics were examined both in new-laid eggs and after 11 to 12 and 22 to 24 days of storage. The loss of weight in the eggs after different periods of storage is considered an indication of the quality of the shell.

EXPERIMENT 4.—SKIM MILK FOR LAYING HENS

The experiment was carried out with 205 White Leghorns, divided into six groups. Groups 1 and 2 were reserved as controls. The remaining four groups (Nos. 3, 4, 5, and 6) were used as experimental groups. Group 3 comprised 30 birds; the other five groups, 35 each. In all groups each hen was given 50 g of grain per day in addition to what dry feed (mixed concentrated feed) she would eat. As a supplement, groups 3, 4, 5, and 6 received milk rations of 40, 70, 100, and 130 g, respectively, per hen. The milk was given in the sour state and as a separate feed.

The protein content of the dry feed was varied in inverse proportion to the size of the milk ration. For the groups taken in order from No. 1 to No. 6, the dry-feed mixtures contained, respectively, 16.2, 16.2, 16.2, 15.2, 13.7, and 12.4 percent of digestible protein. The calculated mean quantity of feed consumed per day by each hen during the period of experiment is shown in table 2.

It appears from table 2 that the milk was consumed practically in accordance with the feeding scheme planned beforehand.

Group 3, which received 40 g of milk, consumed practically the same quantity of dry feed as the control groups and thus received the milk as a direct supplement to the other feed. The other experimental groups consumed about 33 g of dry

[1] 1 gram of feed unit = $\frac{1}{1000}$ Scandinavian feed unit.

feed, or about 5 g less per hen per day than the control groups. The difference between 124 and 69 g of milk has thus not had any influence on the quantity of dry feed consumed. As the quantity of milk given to group 6 was limited to 124 g, it cannot be established from these experiments whether 124 g is the absolutely largest ration that light breeds of hens can consume.

Our impression is, however, that when the hens, as in this experiment, have at the same time access to drinking water, they will not be able to consume any materially larger quantity of milk during a long period of time.

In table 3 is given a general comparison between the quantity of feed consumed and the yield of eggs during the experiment.

As appears from table 3, the yield of eggs, both in number and in average weight, is greater in the experimental than in the control groups and the yield increases with increasing quantities of milk. From the results it is seen that groups 3, 4, 5, and 6 had 6.7, 8.0, 10.8, and 13 percent, respectively, higher yield than the control groups. For every increase of 30 g in the quantity of milk the production of eggs has increased by 2 percent. In a corresponding experiment with medium-heavy breeds, the increase in yield was 7 percent for every 30 g added to the milk ration from 60 to 120 g. On increasing the ration from 120 to 150 g the increase in yield was 3 percent. In this experiment also the milk was given in a sour state and as a separate feed.

The somewhat smaller rise in yield for every increase of 30 g in the milk ration in the light than in the medium-heavy breeds must be regarded in connection with the fact that the control birds in the experiment with the light breeds showed a higher yield of eggs than did the control groups in the experiment with medium-heavy breeds. The reason for this is undoubtedly that the control groups in the experiment with White Leghorns were able to assimilate comparatively more dry feed.

TABLE 2.—*Calculated mean quantity of feed consumed per hen per day*

Feed consumed	Control group—			Experimental group—			
	1	2	Mean for groups 1 and 2	3	4	5	6
	Grams	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
Grain	50	50	50	50	50	50	50
Mixed concentrated feed	39	37	38	38	33	32	34
Skim milk	....	....	....	40	69	98	124
Feed units	89	87	88	94	94	97	103
Digestible protein	10.0	9.8	9.9	11.3	11.2	11.5	12.2
Digestible protein in 1 feed unit	112	113	112	120	119	119	118

TABLE 3.—*Comparison between quantity of feed consumed and egg production during experiment, October 11, 1934 to May 9, 1935 (300 days)*

Item	Control group—			Experimental group—			
	1	2	Mean for groups 1 and 2	3, fed 40 g milk	4, fed 70 g milk	5, fed 100 g milk	6, fed 130 g milk
Total feeding days ....number	9,561	10,078	9,820	8,220	10,177	10,012	10,147
Mean number of hens, calculated	31.9	33.6	32.7	27.4	33.9	33.4	33.8
Mean weight per hen on October 11, 1934 ....kilograms	1.47	1.44	1.46	1.47	1.45	1.42	1.46
Mean weight per hen on May 9, 1935 ....do	1.51	1.47	1.49	1.55	1.57	1.62	1.65
Weight increase per hen during experiment ....grams	40	30	35	80	120	200	190
Grain consumed ....kilograms	478	504	491	411	509	500	507
Mixed concentrate feed consumed ....do	371	373	372	310	338	323	342
Skim milk consumed ....do	....	....	....	329	703	980	1,261
Total eggs laid ....number	6,124	6,771	6,448	5,668	7,182	7,139	7,260
Total weight of eggs laid ....kilograms	322.5	348.5	335.5	299.2	375.1	379.1	391.4
Mean weight of eggs ....grams	52.7	51.5	52.0	52.8	52.2	53.1	53.9
Laying percentage, reckoned in 57-g eggs	59.2	60.7	59.9	63.9	64.7	66.4	67.7

Table 3 shows that the mean size of the eggs of all the milk-fed groups were larger than that of the eggs produced by the control groups, and the largest eggs were produced by group 6, which received the largest ration of milk. However, the increased weight of the eggs after the addition of milk to the diet can hardly be due to any special property of the milk, but to the fact that the milk-fed birds took up a larger total quantity of energy. The size of the egg is, of course, to a large extent an individual characteristic, but it may nevertheless within certain limits be influenced by the feed given to the fowl. The average consumption per kilogram of eggs produced was 2.57 feed units for groups 1 and 2.

For groups 3, 4, and 5 the corresponding feed units were 2.59, 2.57, and 2.58, respectively. In group 6, which consumed 124 g of milk daily per bird, the consumption was 2.66 feed units per kilogram of eggs. The experiment thus seems to show that milk rations up to 100 g have been somewhat better utilized than the ration of 124 g.

Of the total consumption of feed, the milk supplied the percentages shown in table 4.

The health of the fowl was excellent in both experiments.

EFFECT OF MILK FEEDING ON QUALITY OF EGGS

From a nutritional standpoint, hens may be given as much milk as they can consume. For good quality of eggs for table use, however, it appears from our experiments that the quantity ought to be limited to from 80 to 100 g for the light breeds and to 100 to 120 g for the medium-heavy breeds, corresponding to between 15 and 18 percent of the total quantity of feed given.

In the experiment with medium-heavy breeds, 485 eggs were investigated with regard to quality. The smallest milk ration, 60 g, had a favorable influence on the quality of the shell, whereas the larger quantities had somewhat varying results. Whether the greater loss of weight during storage when more than 100 g of milk was given can be ascribed to the milk itself or to the high yield of eggs in these groups cannot be decided with certainty. It is probable that the yield here plays an essential part.

TABLE 4.—*Proportions of total feed supplied by milk*

Group No.	Quantity of milk in ration	Proportion of total feed indicated that was supplied by the milk	
		Feed units	Proteins
	Grams	*Percent*	*Percent*
3	40	7.1	12
4	70	12.5	21.2
5	100	17.2	29.6
6	124	20.1	34.5

The mobility and visibility of the yolk in new-laid eggs have been found to be equal in the control and experimental groups. After the eggs were stored for 11 or 12 days, a greater change in these two properties seemed to have occurred in the milk-fed groups than in the control groups. The difference, however, was so small that it may be considered to be of subordinate importance. After 22 or 24 days of storage, the eggs of the experimental groups showed somewhat inferior keeping properties, but the difference was slight and sometimes insignificant.

The color of the yolk showed no difference in the various groups.

The color of the white, and also the consistency, to some degree, seemed to be favorably influenced by milk feeding.

In the experiment with light breeds, examination of the quality of eggs yielded practically the same results as those in the experiment with the medium-heavy breeds. However, the color and to some degree the consistency of the white are impaired by the use of larger quantities of milk in the feed.

RESULTS OF EXPERIMENTS WITH POTATOES

Potatoes given in addition to the necessary protein-containing rations seem to have no different effect on the laying capacity, weight increase, and health of the fowl than other feedstuffs rich in carbohydrates. The fear that potatoes will have a fattening effect and reduce the yield of eggs is unfounded, provided the rest of the feed is of the proper composition. The health of the fowl used in the experiment was good.

The experiments show that potatoes may be given to laying hens to the extent of 15 percent of their feed requirements. This percentage corresponds to 50 to 60 g for light breeds and to 70 to 80 g for the medium-heavy types.

Examination of 268 eggs were made with respect to quality. The examination showed somewhat varying results, especially as regards the visibility and mobility of the yolk. Feeding of potatoes did not impair the quality of the shell. The weight of the shell increased as the quantity of potatoes in the feed was augmented. The color of the yolk was, in general, favorably affected, but not so much that any importance can be assigned to potatoes in this respect. The color and consistency of the white were, on the whole, favorably influenced.

The eggs from hens fed potatoes showed satisfactory keeping properties on storage during 3 weeks. The visibility and mobility of the yolk seem, however, to have increased somewhat more markedly in eggs from potato-fed fowl.

SUMMARY

The purpose of the experiments was to determine to what extent skim milk and potatoes can be used for laying hens and how these feedstuffs affect egg production, quality of the eggs, and the health and development of the fowl. Both light and medium-heavy breeds were used. Varying quantities of sour skim milk were fed to different lots of birds. The quantities of dry feed consumed by the various lots were practically the same.

In the experiments with skim milk, the yield of eggs, both in number and in average weight, was greater in the experimental than in the control groups, and the yield increased with increasing quantities of milk. The health of the fowl was excellent during the experiments.

From a nutritional standpoint, hens may be given as much milk as they can consume. The experiments showed, however, that to obtain eggs of good quality, not more than 80 to 100 g should be fed to light breeds and 100 to 120 g to medium-heavy breeds, corresponding to between 15 and 18 percent of the total quantity of feed given.

In fresh eggs, mobility and visibility of yolk were equal in control and experimental groups. After storage varying from 11 to 24 days, the eggs from the milk-fed birds were slightly inferior to those of the controls, but the differences were insignificant.

The color of the yolk appeared to be unaffected by milk feeding. The effect of milk feeding on the color and consistency of the white varied with the different breeds.

Potatoes given in addition to the necessary protein-containing rations seem to have no different effect on the laying capacity, weight increase, and health of the fowl than other feedstuffs rich in carbohydrates. The health of the fowl used in the experiment was good.

It was found that potatoes may be fed to laying hens to the extent of 15 percent of their feed requirements. This percentage corresponds to 50 to 60 g for light breeds and to 70 to 80 g for the medium-heavy breeds.

With respect to quality of the eggs, potato feeding had the following results: Varying effects on the visibility and mobility of the yolk, increased the weight of the shell, no appreciable effect on the color of the yolk, improved the color and consistency of the white.

Eggs from potato-fed hens kept well during 3 weeks of storage.

AUFZUCHT MIT WIRTSCHAFTSEIGENEN FUTTERMITTELN, VERSUCH ÜBER DIE VERFÜTTERUNG VON ZUCKERSCHNITZELSCHROT AN KÜKEN

Von DR. HORST MÜLLER, *Geflügelgut Schlobachshof, Böhlitz-Ehrenberg, Deutschland*

Die Zuckerschnitzel haben mit gutem Erfolg Eingang in die Geflügelfütterung gefunden. Nicht nur in der Trockenfuttermischung für Legehennen kann man 10–20 v. H. beigeben, sondern man kann Zuckerschnitzel als Ersatz für Körner verabreichen. Körnerrationen mit $\frac{1}{4}$ bis $\frac{1}{3}$ Zukkerschnitzel werden in der Praxis angewendet, ohne daß die Leistung nachläßt oder Krankheitserscheinungen auftreten. So lag der Gedanke nahe zu prüfen, ob Zuckerschnitzel (fein geschroten) als Ersatz in der Kükengrütze Verwendung finden können. Zu diesem Zwecke wurde auf der Staatl. anerk. Lehranstalt für Geflügelzucht Schlobachshof im Frühjahr 1938 ein Versuch bei Küken (w. Leghorn) angestellt.

VERSUCHSDURCHFÜHRUNG

Die Küken sind am 15.4. geschlüpft. Am 16.4. wurden je 300 Stück in feststehende Aufzuchtsheime (3 x 4 m) gebracht. Zu jedem Heim gehörten 2 Ausläufe, die im Wechsel begangen wurden. Je Küken standen 1 qm Auslauf zur Verfügung. Das Durchschnittsgewicht betrug beim Einsetzen 40 g je Küken. Alle 14 Tage erfolgte eine Wiegung. Am 27.5. wurde mit dem Versuch aufgehört. Eine Trennung der Hähnchen von den Hennchen wurde erst zu Ende des Versuches vorgenommen.

Fütterung.—Die Fütterung wurde folgendermassen durchgeführt: Vom 1. bis 5. Tag erhielten die Küken alle 3–4 Stunden Kükengrütze, ab 6. Tag außerdem eiweißhaltiges Aufzuchtsfutter in trockener Form und Quark. Vom 10. Tag ab wurde das Aufzuchtsfutter in feuchtkrümeliger Form mit reichlich Möhren und Grünfutter vermengt gereicht. Die Kükengrütze wurde dann nur früh und abends je einmal gegeben.

Während die übrige Fütterung in allen Heimen gleich war, ist die Zusammensetzung der Kükengrütze verschieden gewesen.

Heim 1 erhielt Getreidegrütze.
Heim 2 erhielt $\frac{2}{3}$ Getreidegrütze und $\frac{1}{3}$ Zuckerschnitzelschrot.
Heim 3 erhielt $\frac{1}{2}$ Getreidegrütze und $\frac{1}{2}$ Zuckerschnitzelschrot.

Die Getreidegrütze bestand in allen drei Heimen aus $\frac{1}{3}$ Futterweizen und $\frac{2}{3}$ Maisschrot. Die Zukkerschnitzel sind besonders fein geschroten worden.

Die Aufzuchtsmischung setzte sich wie folgt zusammen:

10 v. H. Weizenkleie,
20 v. H. Maisschrot,
10 v. H. Kartoffelflocken,
10 v. H. Zuckerschnitzelschrot,
10 v. H. Haferschrot,
20 v. H. Weizenfuttermehl,
15 v. H. Kozentrat "Promiul",
1 v. H. Holzkohle, fein,
1 v. H. Austernschalenschrot, fein,
1 v. H. Vitakalk,
$1\frac{1}{2}$ v. H. Futterknochenschrot und
$\frac{1}{2}$ v. H. Chlorkalzium.

Der Futterverbrauch betrug in der ersten Hälfte des Versuches (16.4. bis 6.5.):

Heim 1: 33 kg Kükengrütze und 35 kg Aufzuchtsfutter.
Heim 2: 37 kg Kükengrütze und 33 kg Aufzuchsfutter.
Heim 3: 36 kg Kükengrütze und 34 kg Aufzuchtsfutter.

Das Sonderfutter war in allen Heimen das gleiche und zwar: 31,5 kg Quark und 16 kg Möhren. Der Futterverbrauch betrug für die zweite Hälfte des Versuches (7.5. bis 27.5.):

Heim 1: 50 kg Kükengrütze und 126 kg Aufzuchtsfutter.

Heim 2: 48 kg Kükengrütze und 122 kg Aufzuchtsfutter.
Heim 3: 50 kg Kükengrütze und 127 kg Aufzuchtsfutter.

Das Sonderfutter war in allen Heimen gleich und zwar 31,5 kg Quark, 9 kg Möhren sowie Grünfutter. Insgesamt sind verbraucht worden:

	Küken-grütze	Auf-zuchtsf.	Quark	Möh-ren	Grünfutter
	kg	kg	kg	kg	
Heim 1:	83	161	63	25	reichlich
Heim 2:	85	155	63	25	reichlich
Heim 3:	86	161	63	25	reichlich

Wenn man vom Sonderfutter absieht, das in allen Heimen gleichmäßig gegeben wurde, sind insgesamt je Küken verbraucht worden:

a) Erste Hälfte (16.4. bis 6.5.):
Heim 1: 113 g Kükengrütze und 120 g Aufzuchtsfutter.
Heim 2: 130 g Kükengrütze und 116 g Aufzuchtsfutter.
Heim 3: 125 g Kükengrütze und 118 g Aufzuchtsfutter.

b) Zweite Hälfte (7.5. bis 27.5.):
Heim 1: 180 g Kükengrütze und 453 g Aufzuchtsfutter.
Heim 2: 182 g Kükengrütze und 464 g Aufzuchtsfutter.
Heim 3: 188 g Kükengrütze und 478 g Aufzuchtsfutter.

c) Insgesamt:
Heim 1: 293 g Kükengrütze und 573 g Aufzuchtsfutter.
Heim 2: 312 g Kükengrütze und 580 g Aufzuchtsfutter.
Heim 3: 313 g Kükengrütze und 596 g Aufzuchtsfutter.

Ein wesentlicher Unterschied im Futterverbrauch ist nicht zu verzeichnen. Die Küken, die reichlich Zuckerschnitzelschrot erhielten, haben etwas mehr verbraucht. Bei der praktischen Durchführung wurde beobachtet, daß die Küken von Heim 2 und 3 die Kükengrütze nicht so gern aufnahmen. Sie zeigten wenig Freßlust. Auf den Futterbrettchen, die für die Grütze verwendet wurden, blieb Zuckerschnitzelschrot bis zu letzt liegen. Geringe Mengen sind dabei verloren gegangen, sodaß man den Futterverbrauch für alle drei Heime als gleich betrachten kann.

Die Gewichtsfeststellung erfolgte alle 14 Tage frühmorgens:

TABELLE 1.—*Gewichtsfeststellung*

Heim 1

Datum	Zahl der Küken	Gesamtgewicht	Durchschnittsgewicht
		kg	*g*
16.4.	300	12.000	40.0
30.4.	287	23.350	81.3
14.5.	282	45.020	159.6
27.5.	273	64.990	230.5

Heim 2

Datum	Zahl der Küken	Gesamtgewicht	Durchschnittsgewicht
		kg	*g*
16.4.	300	12.000	40.0
30.4.	288	16.625	57.7
14.5.	258	43.800	169.7
27.5.	249	57.300	230.1

Heim 3

Datum	Zahl der Küken	Gesamtgewicht	Durchschnittsgewicht
16.4.	300	12.000	40.0
30.4.	289	17.760	61.4
14.5.	267	34.740	130.1
27.5.	252	56.270	223.3

Aus diesen Zahlen erkennt man, daß Zuckerschnitzelschrot vor allem in der ersten Zeit nicht günstig gewesen ist und daher als Erstlingsfutter für die Küken in größeren Mengen nicht Verwendung finden kann. Im übrigen ist auch die Kükengrütze nicht vielseitig und gehaltvoll genug gewesen in diesem Jahr, weshalb auch die Entwicklung der Küken bei dem Vergleichsheim nicht günstig ausfiel. Nachteilig erwies sich auch, daß die Hähnchen, die sonst beim Erkennen herausgenommen werden, nicht gesondert gehalten wurden.

Während des Versuches waren folgende Verluste zu verzeichnen:

TABELLE 2.—*Verlustziffern*

Datum	Heim 1	Heim 2	Heim 3
	Prozent	*Prozent*	*Prozent*
30.4.	4.3	4.0	3.6
14.5.	6.0	14.0	11.0
27.5.	9.0	17.0	16.0

Die Verlustzahlen liegen bei den Heimen 2 und 3 höher als bei Heim 1. Es war auch zu beobachten, daß die Küken dieser beiden Heime nicht so munter waren. Die Hauptverluste traten im zweiten Abschnitt des Versuches ein. Einige Küken wurden am 18.5. dem Geflügelgesundheitsdienst zur Untersuchung eingesandt. Als Todesursache wurde *Bact. pullorum* festgestellt. Zweifellos liegen Verdauungsstörungen bei den Küken vor, die durch überreichliche Gabe von Zuckerschnitzelschrot hervorgerufen worden sind. Beobachtet wurde auch, daß in Heim 2 und 3 die Einstreu durch Kot stark verklebt war und ein eigentümlich scharfer Geruch auftrat.

Witterung.—Die Witterung war während der Versuchszeit zumeist unbeständig und regnerisch. Für die Aufzucht nachteilig war vor allem die graß wechselnde Witterung.

ZUSAMMENFASSUNG

Die Zuckerschnitzel haben mit Erfolg Eingang in die Geflügelfütterung gefunden und können nach den gesammelten Erfahrungen teilweise die Körnergabe ersetzen. Während bei der Verfütterung an Hennen genaue Versuche vorliegen, war bisher noch kein Versuch bei Küken durchgeführt worden. Es wurde daher im Frühjahr 1938 auf der Staatl. anerk. Lehranstalt Schlobachshof, Böhlitz-Ehrenberg, ein Versuch bei Küken angestellt. Es wurden drei Heime mit je 300 Küken besetzt. Die Küken des Heimes 1 erhielten Getreidegrütze, des Heimes 2 $\frac{2}{3}$ Getreidegrütze und $\frac{1}{3}$ Zuckerschnitzelschrot, des Heimes 3 $\frac{1}{2}$ Getreidegrütze und $\frac{1}{2}$ Zuckerschnitzelschrot. Die Aufzuchtsmischung und das Sonderfutter sind in allen drei Heimen gleich gewesen. Der Verbrauch an Futter wurde genau aufgezeichnet. Das Wiegen der Küken erfolgte aller 14 Tage. Mit Abschluß der 6. Lebenswoche wurde der Versuch abgeschlossen. Die Trennung der Hähnchen von den Hennchen wurde erst zu Ende des Versuches vorgenommen. Die Verlustziffern an Küken wurden jeweils alle 14 Tage angeführt. Den Küken stand Freiauslauf (1 qm je Küken) zur Verfügung, den sie je nach den Witterungsverhältnissen benutzt haben.

Zusammenfassend kann auf Grund dieses Versuches gesagt werden, daß Zuckerschnitzelschrot sich in größeren Mengen für die Verfütterung an Küken nicht eignet. Die Anfangsentwicklung der Küken hat besonders zu wünschen übrig gelassen. Die Verlustziffern an Küken waren größer in den Heimen, in denen Zuckerschnitzelschrot in der Kükengrütze verfüttert wurde. Dieses Futter ist ohne Zweifel für den Kükenmagen schwer verdaulich. Es entstehen Verdauungsstörungen, an denen die Tierchen zugrunde gehen. Man erkennt an diesem Versuch, daß als Futter für die Küken das beste gerade gut genug ist. Für eine erfolgreiche Aufzucht können Ersatzfuttermittel kaum Verwendung finden.

SUMMARY

Ground sugar beets have been successfully adopted as poultry feed, and according to experiences gained, this type of feed may partly be used as a substitute for grain. Thorough investigations as to the suitability of this feedstuff have been made with hens but no experiments had been undertaken so far with chicks. Investigations of this nature were undertaken in the spring of 1938 by the State recognized educational institution Schlobachshof, Böhlitz-Ehrenberg. In this instance 300 chicks were put into each of three brooder houses. The chicks of brooder house No. 1 received cereal groats, the chicks of brooder house No. 2 received two-thirds of cereal groats and one-third of ground sugar beets, and those of brooder house No. 3 received one-half of cereal groats and one-half of ground sugar beets. The mixture of rearing feed and the special feed were the same for all three brooder houses. The consumption of feed was carefully registered. The chicks were weighed every two weeks. The experiment was terminated when the chicks were six weeks old. The cockerels were separated from the pullets only at the end of the experiment. The losses were ascertained every two weeks. There was a range (1 square meter per chick) which the chicks could use according to weather conditions.

In summarizing, it may be said, on the basis of this experiment, that ground sugar beets in large quantities are not suitable as feed for chicks. Particularly the initial development of the chicks left very much to be desired. The losses of chicks were greater in those brooder houses where ground sugar beets were fed with groats. This type of feed is undoubtedly hard for chicks to digest. Digestive disturbances arise which cause the loss of the chicks. This experiment shows that only the best is good enough for chicks. Substitutes can hardly be used for successful rearing.

VERSUCHE ÜBER AUSNUTZUNG UND FUTTERWERT WIRTSCHAFTSEIGENER FUTTERMITTEL

Von Professor Dr. Ernst Mangold, *Direktor des Instituts für Tierernährungslehre der Universität Berlin, Deutschland*

Auf dem 5. Weltgeflügelkongress durfte ich über die Physiologie der Ernährungsvorgänge beim Geflügel berichten, besonders über den Bau und die Funktionen der Verdauungsorgane und die sich in ihnen vollziehenden mechanischen und chemischen Veränderungen der Futtermittel und der in diesen enthaltenen Nährstoffe, deren Verdaulichkeit die Voraussetzung für ihre Ausnutzung im Stoffwechsel dieser Tiere ist.

Auf dem 6. Kongress in Leipzig konnte ich hieran anknüpfend die wichtigsten Grundlagen für die Verwertung der Futtermittel zusammenfassen und besonders die verschiedenen Einflüsse behandeln, die zum Teil durch die Eigenschaften der Futtermittel selbst und ihrer verschiedenen Zusammensetzung je nach Arten und Sorten der Futterpflanzen auf ihre Verdaulichkeit ausgeübt, zum anderen Teil aber von Seiten der Tiere besonders durch ihre individuellen sowie art-und rassenmässigen Unterschiede bedingt werden, und die alle mehr oder minder auch auf die Verwertung des Futters im Erhaltungs-und Produktions-Stoffwechsel des Geflügels einwirken.

Heute möchte ich mich spezielleren Fragen zuwenden und hauptsächlich auf Grund eigener Versuche unseres Instituts über die Ausnutzung und den Futterwert der sogenannten wirtschaftseigenen Futtermittel berichten. Als solche bezeichnen wir alle diejenigen, vorwiegend pflanzlichen, Futtermittel, die in einer Geflügelzucht nicht von fremder Hand gekauft zu werden brauchen, sondern die ihr aus dem grösseren landwirtschaftlichen Betriebe, dem sie angegliedert ist, oder auch aus kleinerem eigenen Anbau, zur Verfügung stehen. Daher haben die wirtschaftseigenen Futtermittel überall dort eine grössere Bedeutung gewonnen, wo die Geflügelwirtschaft nicht isoliert von der übrigen Landwirtschaft betrieben wird, sondern wo sie sich den allgemeinen landwirtschaftlichen Betrieben als organisch zugehöriger Teil eingegliedert hat. Dies ist besonders bei uns in Deutschland der Fall. Aber auch z.B. in Italien überwiegt, wie Ghigi berichtete, die landwirtschaftliche Geflügelhaltung über die industrielle. In solchen Betrieben gilt es, die Futterprodukte der eigenen Wirtschaft auch für die eigene Geflügelhaltung nutzbar zu machen und diese hierdurch zugleich auf eine ökonomisch rationellere Grundlage zu stellen, als wenn das ganze Geflügelfutter aus fremder Produktion gekauft werden müsste.

Naturgemäß sind die wirtschaftseigenen Arten der Futtermittel zum Teil die gleichen wie diejenigen, die von den isolierten Geflügelbetrieben aus der Landwirtschaft gekauft werden. Daher sind unsere Ausführungen über die Verwertung der wirtschaftseigenen Futtermittel auch nicht ausschliesslich für diejenigen Landwirte bestimmt, die ihr Geflügel im Rahmen eines allgemeinen landwirtschaftlichen Betriebes halten; sie wenden sich vielmehr auch zugleich an die Züchter der isolierten und industriell eingerichteten Geflügelbetriebe. Für beide Arten der Geflügelzüchter gemeinsam werden wir ferner diejenigen Ergänzungs-Futtermittel zu erwähnen haben, die auch von den landwirtschaftlichen Geflügelhaltungen gelegentlich zweckmässiger Weise zu ihren wirtschaftseigenen Futtermitteln hinzugekauft werden, weil sie besondere Futterwirkungen haben, welche es ermöglichen, die produktiven Leistungen aus der Geflügelzucht zu steigern. Als solche Zusätze zum Futter werden natürlich besonders tierische Eiweißfuttermittel in Betracht kommen. Denn wir wissen aus zahlreichen vergleichenden Versuchen, auch aus solchen unseres Instituts, dass die Zufütterung von tierischem Eiweiss infolge seiner grösseren biologischen Wertigkeit gegenüber dem Pflanzlichen, in jeder Geflügelzucht mit höheren Leistungen unentbehrlich für die Tiere ist.

Bevor wir nun auf einzelne Futtermittel eingehen, erscheint es zweckmässig, den Blick noch auf einige allgemeine und grundsätzliche, auch methodische, Fragen zu richten. Wenn wir uns hierbei zunächst danach umsehen, auf welche Weise wir uns denn überhaupt ein Bild von der Ausnutzung und dem Futterwert eines Futtermittels machen können, so erinnern wir uns daran, dass eine ganze Reihe von chemischen Analysen, von Tierversuchen und von praktischen Erfahrungen dazu nötig sind, um dieses Bild vollständig auszumalen. Als erstes muss uns die chemische Futteranalyse über die Zusammensetzung und den Nährstoffgehalt des Futtermittels aufklären, damit wir wissen, wie hoch darin der Prozentgehalt an den einzelnen Rohnährstoffen ist, die wir als Rohprotein, Rohfett, Rohfaser, stickstoffreie Extraktstoffe (leicht lösliche Kohlehydrate), bezeichnen, neben denen auch die Mineralstoffe und Vitamine eine wichtige Rolle spielen. Sodann müssen wir durch Tierversuche im Laboratorium, bei denen auch die in den Faeces wieder ausgeschiedenen Nährstoffe analysiert werden, bestimmen, wieviel Prozent von jedem der Nährstoffe im Tierkörper zurückgeblieben sind und daher als verdaut gelten dürfen. Diese Werte für die prozentische Verdaulichkeit, die sog. Verdauungskoeffizienten, gestatten uns, nach der Rohnährstoffanalyse des Futtermittels zu berechnen, wieviel dieses an verdaulichen Nährstoffen der verschiedenen Art für das Geflügel enthält.

Wenn die verschiedenen Futtermittel, die wir verwenden wollen, in dieser Weise geprüft sind, so können wir für die Fütterungsversuche an Legehennen oder an Küken, ausser dem schon durch die Futtermittelanalyse bestimmbaren Roh-Nährstoffverhältnis auch das sogenannte Eiweissverhältnis feststellen, welches zwischen dem verdaulichen Eiweiss und dem verdaulichen Nichteiweiß, d. h. der Summe der verdaulichen Anteile der übrigen Nährstoffe (Rohfett, stickstoffreie Extraktstoffe, Rohfaser) besteht. Dieses Eiweißverhältnis ist darum so wichtig, weil es bekannt ist, dass die besten Futterwirkungen erzielt werden, wenn dasselbe bei Junggeflügel und Legehühnern 1:3 bis 4, bei Fleischmast 1:5 und bei Fettmast 1:9 beträgt. Dies wird durch die ganz allgemein den Stoffwechsel steigernde Wirkung des Eiweiss bedingt, ohne welche auch die übrigen Nährstoffe nicht so gut im Tierkörper ausgenutzt werden können. Anstatt das Eiweissverhältnis anzugeben, kann auch der prozentische Anteil des Eiweiss am Gesamtfutter angegeben werden, wie es besonders durch die amerikanischen Forscher geschieht. Jedenfalls ist es bei Fütterungsversuchen, in denen die Futterwirkung verschiedener Futtermittel an mehreren Gruppen von Hennen oder von Küken verglichen werden soll, unerlässlich, das Eiweißverhältnis oder den Prozentgehalt an Eiweiss in allen Versuchsgruppen möglichst gleich zu gestalten, da allein schon durch dessen Verschiedenheit Unterschiede in der Eiproduktion oder im Wachstum hervorgerufen werden können, welche die sonstigen Unterschiede zwischen den zu vergleichenden Futtermitteln verschleiern.

Durch die in der hier angedeuteten Weise ausgeführten Fütterungsversuche z. B. an Legehennen oder Küken ist es nun auch möglich, den Futterwert eines Futtermittels für sich oder im Vergleich zu anderen zu bestimmen und zahlenmässig festzulegen. Hierfür ist es nur noch erforderlich, dass während des ganzen Versuches auch die Futteraufnahme der einzelnen Gruppen genau kontrolliert wird, so dass für jede Gruppe die von ihr verzehrten Mengen der einzelnen Futtermittel angegeben werden können. Aus den Nährstoffanalysen lässt sich dann der Verzehr an Rohnährstoffen, und aus den Verdauungskoeffizienten auch der an verdaulichen Nährstoffen berechnen. Als Maßstab für den Futterwert dient hierbei die Menge an Rohnährstoffen und im einzelnen auch an Rohprotein, die für die Produktions-Einheit der Eierleistung, z. B. für 100 g Eisubstanz oder für 100 g Gewichtszunahme beim Wachstum der Küken, in den verschiedenen Gruppen durchschnittlich erforderlich war. Je kleiner diese Zahl ist, desto besser war die Futterverwertung. Während dieses Verhältnis der Rohstoffmenge zur Produktionsmenge einen guten Maßstab für die Futterverwertung gibt, der auch insofern mehr den praktischen Bedingungen entspricht, als den Tieren das Futter ja auch mit allen seinen Rohnährstoffen verfüttert wird, hat F. Lehmann, dem wir die Berechnung der Futterverwertung nach solchen Verwertungszahlen verdanken, hauptsächlich deren Berechnung nach verdaulichen Nährstoffen empfohlen; diese hat indessen mit den Ungenauigkeiten zu rechnen, die davon herrühren, dass die Verdauungskoeffizienten der üblichen Tabellen nicht ohne weiteres für jeden einzelnen Fütterungsversuch zutreffen, sondern, wie schon erwähnt, manchen Schwankungen unterworfen sind.

Auf die energetische Ausnutzung und die Verwertung des Futters nach seinem Caloriengehalt im Stoffwechsel des Geflügels will ich hier nicht eingehen. Wenn auch das Gesamtbild vom Stoffwechsel eines Tieres erst durch die Untersuchung seines Gaswechsels mittelst des Respirationsapparates vervollständigt wird, aus der sich der Energieumsatz im Tierkörper ergibt und auch die Art der Verwertung der Nährstoffe erschliessen lässt, so sind diese Dinge doch gerade am Geflügel noch viel zu wenig untersucht und daher auch methodisch noch nicht genügend für unsere Fragen nutzbar gemacht.

Besonders für die praktischen Zwecke der Geflügelernährung handelt es sich ja meist in erster Linie darum, zu entscheiden, ob ein Futtermittel, dessen Futterwert noch nicht bekannt ist, eine gute Ausnutzung und lohnende Verwertung zeigt, wofür dasselbe meist in Gruppenversuchen mit anderen bekannten Futtermitteln verglichen und seine Futterverwertung zahlenmässig festgestellt wird. Daher möchte ich hier nur kurz noch eine neue Methode zur Futterwertbestimmung beim Geflügel beschreiben, die wir selbst gerade in der letzten Zeit in Versuchen mit H. Damköhler zu entwickeln versucht haben:

An einer möglichst grossen Zahl von Küken-Gruppen, die unter völlig gleichen Bedingungen in Stallabteilungen mit abgeschlossenen Ausläufen gehalten werden, so dass jede unkontrollierte Futteraufnahme ausgeschlossen ist, werden, nachdem alle Gruppen zunächst 2 Wochen lang mit einem normalen Futtergemisch aufgezogen worden sind, um hierbei die Übereinstimmung der Gruppen in ihren Gewichtszunahmen festzustellen und zugleich die Gesundheit und Widerstandsfähigkeit der Küken zu kräftigen, hieran anschliessend vergleichende Fütterungsversuche durchgeführt. Hierbei erhalten alle Gruppen als einfaches und allgemein brauchbares Grundfutter Gerstenschrot und jede Gruppe dazu noch die Zulage eines der auf ihren Futterwert zu vergleichenden Futtermittel. Um den Einfluss des Unterschiedes des Nährstoffverhältnisses auf das Wachstum der Küken auszuschalten, muss das Nährstoffverhältnis, oder gegebenenfalls das Eiweissverhältnis des Futters in allen Gruppen durch entsprechende Bemessung der Anteile von Gerstenschrot und Beifutter möglichst ausgeglichen werden. Diese Versuche mit verschiedener Gruppenfütterung sind 6–8 Wochen fortzusetzen. Als normale Vergleichsgruppe ist eine Kükengruppe mit einem normalen Körnermischfutter und Fischmehlbeigabe mitzuführen. Wenn dann die gesamte Gewichtszunahme dieser Normalgruppe vom Beginn bis zum Abschluss der Versuche gleich 100 gesetzt wird, so können aus den Gewichtszunahmen der übrigen Gruppen für diese die auf 100 der Normalgruppe bezogenen Zahlen berechnet werden. Diese Zahlen können als Vergleichswerte für die Verwertung der verschiedenen Futtermittel, also als Futterverwertungszahlen, zum Anhaltspunkt für die Beurteilung ihres Futterwertes für die Kükenaufzucht dienen.

Dieses Verfahren kann auch für die Futterwertbestimmung von Futtermitteln bei Legehennen in gleicher Weise, nur unter Verwendung der Eierproduktion anstatt der Gewichtszunahmen, angewendent werden.

Mit dieser Methode erscheint es uns verhältnismässig leicht durchführbar, durch eine grosse Zahl solcher Versuche sowohl pflanzliche und tierische Futtermittel unter sich und gegeneinander zu vergleichen, wie auch besonders die einzelnen Körnerarten und sonstigen wirtschaftseigenen Futtermittel und ihre Mischungen auf ihren, das Gerstenschrot ergänzenden Futterwert zu prüfen, um hierdurch zu den für die Kükenaufzucht oder für Legehennen am besten geeigneten und möglichst einfachen und billigen Futterzusammenstellungen zu gelangen.

Nachdem ich nun einige mir besonders wichtig scheinende allgemeine, grundsätzliche und methodische Fragen in Bezug auf Ausnutzung und Futterwert der Futtermittel beim Geflügel besprochen habe, die ich gern in diesem Kreise zur Diskussion stellen wollte, will ich zu unseren Versuchen über wirtschaftseigene Futtermittel übergehen.

Als wirtschaftseigenes Grundfutter besitzt für die praktische Fütterung des Geflügels wohl stets ein Getreidekörnerschrot-Mischfutter die grösste Bedeutung. Dieses kann aus Schroten, Kleien, und zum Teil auch Schalen, der Getreidearten bestehen, von denen hauptsächlich Gerste, Mais, Hafer, Weizen, Roggen in Betracht kommen.

Über die Ausnutzung dieser Körnerarten ist zu sagen, dass wir in unseren, im Laufe der letzten Jahre mehrfach an verschiedenen Hühnerrassen ausgeführten Stoffwechselversuchen meist etwas höhere Verdauungskoeffizienten für das Rohprotein feststellen konnten als die Arbeiten und Tabellen der früheren Literaturangaben. So fanden wir für die Eiweiss-Verdaulichkeit beim Mais 81–87 Prozent, bei Hafer 71–85, beim Weizen 77–86, bei Roggen 65–73 Prozent, und auch für Hirse mit 88 und Reis mit 83 Prozent fand Stotz bei uns höhere Werte als die früheren Autoren. Dies mag zum Teil methodisch bedingt sein, indem wir bei der Bestimmung der Eiweiss-Verdaulichkeit beim Geflügel die von Stotz ausgearbeitete Methode anwandten, bei der durch Oxydation mit Salpetersäure eine chemische Abtrennung des Harn-Stickstoffs von dem Kote stattfindet, wie sie auch durch die Methode von John und Johnson erstrebt wird. Wir glauben, dass nur eine solche, Harn und Kot auf chemischem und nicht auf operativen Wege trennende Methode normale Werte für die Eiweiss-Verdaulichkeit geben kann.

Unsere neueren Versuche mit Hock haben übrigens gezeigt dass die Tauben das Rohprotein ihrer Futterkörner, zu denen hier in höherem Masse als bei den Hühnern auch die der Leguminosen gehören, durchweg um 5–14 Prozent und im Durchschnitt um 8 Prozent besser zu verdauen vermögen als die Hühner. Hierdurch bestätigt es sich, wie notwendig es ist, die Verdaulichkeit der einzelnen Futtermittel, die bisher fast ausschliesslich nur an Hühnern bestimmt wurde, wonach die erhaltenen Werte für die Verdauungskoeffizienten und für den Gehalt an verdaulichen Nährstoffen dann aber meist als allgemein für "das Geflügel" geltend angesehen wurden, nun auch getrennt für die verschiedenen Geflügelarten zu untersuchen.

Es ist selbstverständlich, dass die erwähnten Unterschiede in der Versuchsmethodik auch auf diejenigen Zahlen ihren Einfluß ausüben, die bei der indirekten Berechnung der Verdauungskoeffizienten für die stickstoffreien Extraktstoffe, d. h. für die leichtlöslichen Kohlehydrate, erhalten werden. Diese Kohlehydrate bilden aber den Hauptbestandteil des Geflügelfutters, so dass ihre Ausnutzung und der Futterwert der kohlehydratreichen Futtermittel uns besonders interessieren müssen.

Unter den wirtschaftseigenen Futtermitteln hat nun in letter Zeit neben Getreide und Hülsenfrüchten, Runkel- und Mohrrüben, Kohl und Luzerne, besonders als Kohlehydratträger immer mehr die Kartoffel an Bedeutung gewonnen, die im gekochten Zustande für die Fütterung der Hühner allgemein empfohlen wird. Jedoch darf ihre Verwendung niemals so einseitig werden, wie es gelegentlich eine reine Körnerfütterung ohne Schaden werden darf. Denn die Kartoffel ist infolge ihres hohen Wassergehaltes sehr voluminös, so dass sie im Verdauungskanal der Tiere den Platz für konzentriertere Futtermittel wegnimmt und in zu grossen Mengen zu Durchfällen führt, die ihre eigene Ausnutzung beeinträchtigen und nur teilweise durch Beifütterung von Holzkohle verhütet werden können.

Ausserdem hat es mit der Kartoffelstärke verdauungspysiologisch noch eine besondere Bewandtnis. Wie A. Hock in unserem Institut durch Stoffwechselversuche an Hühnern gezeigt hat, wird nämlich rohe Kartoffelstärke zwar, wenn sie nur einen geringen Teil der gesamten Futterration ausmacht, bis zu 93 Prozent verdaut, bei steigendem Anteil aber nur zu 60–70 und schliesslich nur noch zu 36 Prozent. Auch kommt sie, wie Hock durch getrennte Analysen des Inhaltes der verschiedenen Darmabschnitte von Hühnern nachweisen konnte, im oberen Dünndarm nur zu etwa 40 Prozent zur Auflösung, während die rohe Stärke der Getreidekörner hier bereits restlos verschwindet und im ganzen stets zu 94–100 Prozent verdaut wird. Auch bei Kartoffeln und Kartoffelprodukten kann aber für die praktische Fütterung eine vollständige Ausnutzung der Stärke gewährleistet werden, wenn diese vorher durch Dämpfen der Kartoffeln oder Herstellung von Kartoffelflocken für die Verdauung aufgeschlossen ist.

Aus diesen Versuchen von Hock an Hühnern und Tauben wie auch an Schweinen ergibt sich ganz allgemein, dass wir für die Beurteilung des Futterwertes eines Futtermittels hinsichtlich der Verdaulichkeit der stickstofffreien Extraktstoffe, im Gegensatze zu der bisherigen summarischen Betrachtungsweise, zwischen dem Stärke-Anteil und dem Nicht-Stärke-Anteil der stickstofffreien Extraktstoffe unterscheiden müssen. Denn diese Versuche ergaben, dass das Schwein im allgemeinen die gesamten stickstofffreien Extraktstoffe, somit also auch ihren Nicht-Stärke-Anteil, der im wesentlichen aus Extrakt-Pentosanen und Ligninen besteht, zu 90–100 Prozent verdaut, während Hühner und Tauben fast ausschliesslich den Stärke-Anteil zu verdauen vermögen. Der Vergleich mit den in gleicher Weise differenzierten Kohlehydrat-Analysen der Futtermittel zeigte dabei, dass beim Geflügel die N-freien Extraktstoffe fast genau in demselben Masse verdaut werden, als sie aus Stärke bestehen. Aus diesem Grunde bleiben auch von den Nährstoffen der Süßlupinen, die sich im übrigen als ein neu gezüchtetes Futtermittel besonders wegen ihres hohen Gehaltes an hochwertigem Eiweiss in unseren Versuchen als Eiweissfutter für die Geflügelernährung sehr bewährten, die stickstoffreien Extraktstoffe bei dem Geflügel so gut wie unverdaulich, weil sie keine Stärke enthalten.

Für die praktischen Zwecke der Futterberechnung ergibt sich aus dem Gesagten, dass die Verdaulichkeit der stickstofffreien Extraktstoffe in den Futtermitteln für das Geflügel keineswegs nach ihrem Prozentgehalt an diesen Extraktstoffen, sondern nur nach ihrem Gehalt an Stärke beurteilt werden kann.

Bezüglich der Kartoffel möchte ich noch darauf hinweisen, dass sie zwar prozentisch ja nur wenig Eiweiss enthält, durch den Umfang ihrer Welt-produktion aber ungeheure Eiweissmengen liefert. Entsprechend unserem allgemein bestehenden hohen Eiweissbedarf für die menschliche und tierische Ernährung wird nun heute in Deutschland das bei der Stärkefabrikation bisher mit dem abfliessenden Kartoffelsafte verloren gegangene Eiweiss besonders nach den von W. Kröner entwickelten technologischen Verfahren in Gestalt von Kartoffeleiweissflocken gewommen. Dieses Kartoffeleiweiss, das nach meinen mit A. Columbus an Schweinen nach der Methode von H. Mitchell ausgeführten Versuchen für Erhaltung und Wachstum die sehr hohe biologische Wertigkeit von 79–88 Prozent aufweist, eignet sich nach unseren Versuchen mit Damköhler auch als Eiweissbeifutter für die Kükenaufzucht, allerdings nur unter der Voraussetzung, dass dieses pflanzliche Eiweiss noch durch die Beigabe von tierischem Eiweiss ergänzt wird.

Solche zusätzliche tierische Eiweissfuttermittel stehen bekanntlich in grösserer Auswahl zur Verfügung. Besonders bewährt sind die Fischmehle und nächst diesen die Fleischmehle, Fleischabfälle, Blutmehl, ferner auch allerlei Produkte aus niederen Tieren. Es treten auch immer neue tierische Eiweissfuttermittel auf. Ich möchte hier erwähnen, dass wir sowohl mit der Wollhandkrabbe (Eriocheir sinensis), die aus China in unsere Flüsse eingewandert ist und, als Schrot zerkleinert, etwa 33 Prozent Rohprotein enthält, wie auch mit den von der Seidengewinnung abfallenden Puppen des Seidenspinners (Bombyx mori), die schon längst in Italien als Vogelfutter Verwendung finden und die nach der Extraktion des Fettes 74 Prozent Rohprotein enthalten, in eigenen Küken-Aufzuchtversuchen günstige Erfahrungen über ihre Eignung als hochwertige tierische Eiweissbeigaben machen konnten.

Doch auch die wirtschaftseigene Haltung bietet dem Geflügel zusätzliche tierische Eiweißstoffe. Solche werden von den Tieren schon im Auslauf in Gestalt von Würmern, Insekten und Schnecken aufgenommen. Als das wichtigste wirtschaftseigene tierische Eiweissfuttermittel hat sich aber die Magermilch in ihrer Verwendung weit verbreitet und in ihren Wirkungen ausserordentlich bewährt. Sie vermag den zusätzlichen Bedarf an tierischem Eiweiss durchaus allein zu decken. In diesem Sinne haben die gemeinschaftlich durchgeführten Arbeiten von Bünger, Fangauf, Jaeger, Weinmiller, den Nachweis erbracht, dass die Fütterung der Legehennen bei Verwendung von Magermilch allein mit wirtschaftseigenem Futter bestritten werden kann. Und ich habe mit Damköhler in erstmaligen Küken-Aufzuchtversuchen mit Magermilch an Rhodeländern vom zweiten Lebenstage an gefunden, dass es durchaus möglich ist, die Küken mit steigenden Tagesgaben von 10 bis 90 cc Magermilch als einzigem Eiweissfuttermittel bis zum 5. oder 6. Lebensmonat bei optimaler Entwicklung aufzuziehen. Hierbei hielten die Küken bemerkenswerter Weise bei ihrer ad libitum gebotenen Milchaufnahme das gleiche Nährstoff-Verhältnis (Rohprotein: stickstoffreie Rohnährstoffe) von 1:5 ein, wie die Küken der mit bestimmten Fischmehlgaben gefütterten Kontrollgruppe. Die Futterverwertungszahlen (Nährstoffmenge pro Einheit der Gewichtszunahme) lagen in den Gruppen mit Magermilch und mit Fischmehl für die verdaulichen Nährstoffe in ziemlich gleicher Höhe.

Diese Versuche wurden von uns dreimal nacheinander durchgeführt, und zwar mit im März, im April und im Mai geschlüpften Küken, um so zugleich auch den Einfluss des Schlupfmonats auf die Entwicklung und Futterverwertung der Küken feststellen zu können. Hierbei ergab der Vergleich der März- und Mai-Gruppen, dass die Maitiere, sowohl bei freiwilliger Aufnahme von Magermilch wie bei Verabreichung bestimmter Mengen Fischmehl, die Märztiere bis zum 5. Lebensmonat in ihrem Gewicht praktisch fast vollkommen erreichten, indem sie sich auf einen höheren Futterverzehr und, wie die Berechnung der Verwertungszahlen zeigte, auch auf eine bessere Futterverwertung eingestellt hatten.

Bezüglich der Magermilch will ich im übrigen hier nur noch darauf hinweisen, dass die Milch und Milchprodukte, besonders die getrocknete Magermilch, sich auch in anderen Ländern, und gerade besonders hier in U. S. A., in der Geflügelfütterung bestens bewährt haben, wie zahlreiche Arbeiten der hiesigen Kollegen beweisen.

Es kann im Rahmen meines Themas nicht näher behandelt werden, darf aber auch wohl nicht unerwähnt bleiben, dass für die Ausnutzung und den Futterwert aller und so auch der wirtschaftseigenen Futtermittel, ausser dem Gehalt an den verdaulichen Hauptnährstoffen Rohprotein, Rohfett, leicht löslichen Kohlehydraten sowie an den meist geringen Anteilen verdaulicher Rohfaser, auch die Zusammensetzung des Gesamtfutters und dessen Gehalt an unverdaulicher Rohfaser, die nur einen die Verdauung anregenden Ballast bildet, sowie an Mineralstoffen und Vitaminen, eine grosse Bedeutung haben. Sofern die letztgenannten Stoffe nicht ohnehin schon in genügender Menge im Futter vorhanden sind, muss natürlich für die Verabreichung von mineralischen Futterzusätzen, besonders von Kalk, aber auch Kochsalz (Halnan), und notwendigen Falles auch von Vitaminen gesorgt werden, unter denen das wichtigste, das antirachitische Vitamin D, im Lebertran, aber auch in der Milch enthalten ist und zum Teil durch Licht und Bestrahlung ersetzt werden kann.

Unter den mineralischen Zusätzen spielt noch der Grit eine Rolle, und zwar eine zweifache, indem er, sofern er aus löslichen Kalksalzen besteht, der Mineralzufuhr dient, dagegen als unlöslicher Flintgrit im Muskelmagen die mechanische Zerkleinerung der Futterkörner unterstützt. Über diese Wirkung habe ich in der letzten Zeit mit Hock und Damköhler Versuche durchgeführt, die ergaben, dass die Gritbeigabe weder imstande war, die Verdaulichkeit der Nährstoffe ganzer Gerstenkörner merklich zu steigern, noch auch bei der Aufzucht von Küken die Gewichtszunahmen eindeutig zu verbessern.

Wir möchten aber aus diesem negativen Ausfall vergleichender Aufzucht- und Verdaulichkeits-Versuche doch nicht den Schluss ziehen, dass die bei unserem Geflügel wie bei vielen wildlebenden Vögeln instinktmässig bedingte Aufnahme von Steinchen und Sand keine biologische Bedeutung habe. In solchen Versuchen treten leicht kompensatorische Mechanismen ein, die einen Mangel verdecken können. Daher halten wir es nach wie vor aus biologischen Gründen für richtig, dem Geflügel einen harten, unlöslichen Grit als Futterzusatz nicht vorzuenthalten.

Übrigens haben wir erst nach der Beendigung unserer erwähnten Gritversuche bemerkt, dass bereits Buckner, Martin und Peter, sowie Bethke und Kennard, die gleichen Versuche über Grit bei Kükenaufzucht, und J. C. Fritz ähnliche Versuche über die Verdauungswirkung, angestellt, und dass wir nur ihre Ergebnisse bestätigt haben.

ZUSAMMENFASSUNG

Einleitend wurden einige allgemeine, grundsätzliche und methodische Fragen über die experimentelle Festellung und über die Bedeutung der Ausnutzung und des Futterwertes der Futtermittel beim Geflügel näher besprochen. Hierbei wurde ein neues Verfahren zur vergleichenden Bestimmung des Futterwertes von Futtermitteln an Gruppen von Küken oder Legehennen vorgeschlagen. Hiernach wurde, nach den eigenen Versuchen des Instituts für Tierernährungslehre der Universität Berlin, über die Ausnutzung und den Futterwert der wirtschaftseigenen Futtermittel berichtet, die besonders für die Geflügelhaltung der landwirtschaftlichen Betriebe von Bedeutung, zum Teil aber nuch mit den in isolierten Geflügelwirtschaften verwendeten Futtermitteln identisch sind. Bei den Cerealien ergaben die Versuche an Hühnern für das Rohprotein grösstenteils eine höhere Verdaulichkeit, als den in den Arbeiten und Tabellen der Literatur angegebenen Verdauungskoeffizienten entsprach. Als wirtschaftseigenes tierisches Eiweissfuttermittel bewährte sich auch für die Kükenaufzucht die Magermilch. Bei den Aufzuchtversuchen zeigte sich, dass die späteren Schlupfe (Mai) durch erhöhte Aufnahme und Verwertung des Futters die Gewichtszunahmen der früheren (März) erreichen können. Die Tauben sind den Hühnern in der Ausnutzung der Nährstoffe zum Teil überlegen, besonders hinsichtlich der Eiweissverdauung.

Als wirtschaftseigenes Futtermittel bewährten sich auch die gedämpften Kartoffeln. Rohe Kartoffelstärke wird von den Hühnern mit steigenden Mengen um so schlechter verdaut, während die Stärke der Cerealien auch im rohen Zustande zum grössten Teil schon im oberen Dünndarm durch die Verdauung aufgelöst wird. Allgemein vermögen Hühner und Tauben von den stickstofffreien Extraktstoffen nur den Stärke-Anteil, nicht aber den Nicht-Stärke-Anteil, zu verdauen.

Als zusätzliches Eiweissfuttermittel können auch Kartoffeleiweissflocken, ein Nebenprodukt der Stärkefabrikation, für die Geflügelfütterung verwendet werden. Doch muss der Eiweissbedarf stets noch durch tierische Eiweissfuttermittel ergänzt werden, deren Eiweiss die höhere biologische Wertigkeit besitzt. Als solche bewährten sich neben Magermilch unter anderen auch die Puppen des Seidenspinners und geschrotene Wollhandkrabben.

Der Grit dient in löslicher Form als Kalkfuttermittel, als unlöslicher Grit aber zur mechanischen Zerkleinerung der Körner im Magen. Es wurde zwar in Versuchen gefunden, dass auch der Grit der letzteren Art die Verdaulichkeit der Nährstoffe des Futters und auch die Gewichtszunahmen der Küken nicht wesentlich zu steigern vermochte; doch wird es aus biologischen Gründen für richtig gehalten, dem Geflügel einen harten, unlöslichen Grit zu verabreichen.

SUMMARY

The report is based on experiments of the Berlin University Institute for Animal Nutrition. These experiments deal with the value of home-grown feeds. These feeds are of particular importance to the poultry-raising enterprises, but to a certain extent are also important to isolated poultry farms. Experiments on the feeding of cereals showed, in most cases, a higher digestibility of protein than is indicated by digestion coefficients contained in books and tables. Skim milk, an animal protein foodstuff of home production, also proved to be suitable for rearing chicks. The experiments showed that, by more intensive consumption and utilization of feed, chicks hatched in May weighed practically the same in five months as the chicks hatched in March. In some respects, particularly in the digestion of protein, pigeons are superior to chickens in regard to the utilization of feed.

Steamed potatoes as home-grown feed also led to good results. With fowls the degree of digestion of potato starch decreases with increasing volume. Less than half of the raw potato starch is dissolved by digestion in the upper portion of the small intestine, whereas the greater part of the starch of cereals in a raw state is dissolved there. Generally, chickens and pigeons are able to digest only the amylacious portion but not the non-amylacious portion of non-nitrogenous extractives.

Potato-protein flakes, a byproduct of starch production, may be used as supplementary protein feed for poultry. However, the necessary quantity of protein must always be supplemented by animal protein feed which is of higher biological value. In addition to skim milk,

cocoons and coarsely ground crabs (*Eriocheir sinensis*) led to good results as animal-protein feeds.

Grit in soluble form is a source of lime, and the feeding of insoluble grit results in the mechanical disintegration of grains in the stomach. It has been confirmed, however, that the latter type does not noticeably contribute to the digestibility of nutritive substances and to the increase of the weight of chickens.

THE GENERAL NUTRITIVE VALUE (ENERGY VALUE) OF POULTRY FEED

By PROF. DR. JOEL AXELSSON, *The Agricultural College of Sweden, Uppsala, Sweden*

In many countries the general nutritive value of feed used for poultry is not given, but merely a general description of feedstuffs, together with convenient standard feed rations. This system is not satisfactory because the requirement or consumption of feed cannot be given in a general unit. It would, therefore, be desirable to express the value of feed for poultry, as for ruminants, in a convenient feed unit. However, the use of the same feed unit for poultry as for ruminants is not satisfactory, in that the ability of chickens to digest feed is different from that of ruminants. From the author's investigation and synthesis of earlier experiments, it has been shown that the ability of chickens to digest the nutrients in feed without fiber agrees, to all practical purposes, with that of ruminants, but with an increasing percentage of fiber in the dry matter of the feed chickens do not show the same ability as ruminants. Even with 10 percent of fiber, chickens can use only about 73 percent as much of the organic substance as can ruminants. If the relative quantity of fiber in the dry matter is increased to about 30 percent, the ability of chickens to utilize the organic substance decreases to about one-half that of ruminants.

This condition illustrates that the evaluation of feedstuffs for poultry must be made by some method other than that used for ruminants. This has been done in Germany, for example, where a system developed by Lehmann (1937) has come into use. By this method, both the amount of digestible nutrients and that of ballast in the feed are calculated. By the proper balancing of the relationship between these two quantities, good results can be obtained in the evaluation of the feed and the regulation of the feeding. The system is, however, rather laborious and faulty in that no provision is made for the different amounts of energy in the nutrients.

In consequence of the developments, during the last decades, of the physiology and science of feeding, the demand has arisen that poultry feed be evaluated according to its energy value. However, it does not follow that the net energy should be taken as the basis for the evaluation. The results achieved in attempting to determine the net energy of feedstuffs—whether this is expressed in starch unit, feed unit, or therm—give little promise for a continuation along this line.

As far as the starch unit is concerned, it is characterized in the first place by the fact that the digestible energy in every feedstuff is estimated by the use of experimentally determined factors. As Kellner, reported by Kellner and Fingerling (1919) has shown, and as has been further demonstrated by the present author (1936), these factors are mainly a function of the percentage of fiber in the dry matter of the feedstuffs. However, it is obvious that domestic animals definitely require crude fiber if the feed energy is to be satisfactorily utilized. Therefore, it must be postulated that there is an optimum percentage of fiber at which the maximum amount of net energy is obtained from the feed energy. Instead, in the determination of the net energy of the feed, the starch unit has become a function of the percentage of fiber in the dry matter. The result of this is, therefore, that the animals cannot thrive when they are given feed with a factor of 100 for the digestible nutrients, despite the fact that this is supposed to represent full value and should thus be the best possible. The animals cannot begin to utilize the feed until the factor is considerably less than 100. The utilization gradually increases as the factor decreases to the point where the optimum amount of fiber is reached.

The Scandinavian feed unit is based on Kellner's factors and thus has the same fundamental error as the starch unit. It was further assumed that the digestible protein's entire calorie value could be considered as forming the basis for the net energy. However, it is now clear that when the Scandinavian feed unit was formed the energy value of the feed was confused with the value of protein and to some extent also with the value of vitamins and minerals. Thus, in developing the starch unit, Kellner disregarded the need of an optimum amount of fiber in the feed, and in developing the Scandinavian feed unit there was also a disregard for the fact that optimum amounts of protein, vitamins, and minerals are demanded for determination of the net energy of the different foodstuffs.

That even Armsby failed to determine satisfactorily the net energy content of the feed seems now to be clear. As a result, Forbes and Kriss (1932) are of the opinion that no usable method for the determination of the amount of net energy in the different feedstuffs has yet been developed. Thus, as the amount of net energy in the feed of ruminants cannot be satisfactorily determined, there is at present no possibility of evaluating poultry feeds in terms of net energy.

An evaluation of poultry feed according to the amount of energy seems, however, possible. For this purpose, it seems that the amount of metabolizable energy in the feed should be preferred to the amount of digestible energy. A gram of digestible protein contains, on an average, 5.7 calories, of which 1.0 calorie is not converted in the body. Thus, there is obtained for each gram of digestible protein an average of 4.7 calories of metabolizable energy. In contrast to the protein, the energy of the digestible fat is entirely metabolizable. Depending on the kind of feed, the energy of the fat varies from 7.8 to 9.3 calories per gram. The crude fat, as customarily determined, has, however, a somewhat lower calorie value, because during the extraction certain substances of lower energy value are removed along with the true fat. In that which follows, Kellner's values for the fats from the different classes of feeds are used, e.g., the fat from feed of animal origin and oil-bearing seeds contains 8.8 calories per gram, fat from the cereal seeds 8.3 calories, and that from the coarser feedstuffs 7.8 calories. As far as carbohydrates are concerned, certain losses of energy occur with the development of intestinal gases. Furthermore, there are included also in this group certain substances low in energy, for which reason only 3.8 calories of metabolizable energy can be calculated per gram of digestible carbohydrates.

TABLE 1.—*Metabolizable energy of barley per gram of digestible nutrients and per kilogram of feed*

Nutrients	Quantity of nutrient per gram of barley	Digestible coefficient	Digestible nutrients per kilogram of barley	Metabolizable energy of barley per— Gram of digestible nutrients	Metabolizable energy of barley per— Kilogram of feed
	Grams		*Grams*	*Calories*	*Calories*
Crude protein	100	0.78	78.0	4.7	367
Crude fat	20	.82	16.4	8.3	136
Nitrogen-free extract	680	.85	578.0	3.8	2,196
Fiber	44	.08	3.5	3.8	13
Total			675.9		2,712

For feed of animal origin it seems justifiable to question whether the amount of metabolizable energy could not be calculated as 9.3 calories per gram of digestible fat. If calculated in that way, the metabolizable energy of fat from oil-bearing seeds should be 8.8 calories per gram. It is also a debatable point whether a somewhat lower value should not be used for sugar than for starch and fiber, in which case the amount of convertible energy per gram of digestible carbohydrates in feeds especially rich in sugar should be considered as less than 3.8 calories.

With a knowledge of the composition of the feedstuff and the digestibility of the nutrients, it is possible, with the help of the foregoing facts, to calculate the amount of metabolizable energy per kilogram of feed. As an illustration, the calculation for barley is given in table 1.

Barley with the composition and digestibility of that shown in table 1 should thus contain 2,712 metabolizable calories per kilogram. As barley is very uniform in composition, this feedstuff can advantageously be taken as a base in the the evaluation of foodstuffs. This has been done in the case of the Scandinavian feed unit. A feed unit for poultry, consequently, should be considered as 1 kg of normal barley or the quantity of any other feedstuff which is calculated to give 2,712 metabolizable calories. This method of evaluation is easy to carry through and gives a fully acceptable result as definite digestibility coefficients are obtained for the different foodstuffs.

TABLE 2.—*Evaluation of some of the most important poultry feedstuffs*

Feedstuff	Dry matter	Metabolizable energy per kilogram of feed	Quantity of feed in feed unit: Total feed	Quantity of feed in feed unit: Dry matter
	Percent	*Calories*	*Kilograms*	*Kilograms*
Beets, roots	12.0	343	7.94	0.95
Rye	87.0	2,798	.97	.84
Wheat	87.0	2,904	.93	.81
Barley	87.0	2,712	1.00	.87
Oats	87.0	2,303	1.18	1.03
Corn	87.0	3,086	.88	.77
Wheat middlings	87.0	2,809	.96	.84
Wheat bran	87.0	1,836	1.48	1.29
Linseed cakes	88.5	2,835	.95	.84
Skim milk, fresh	9.2	335	8.07	.74
Skim milk, dried	93.0	3,307	.82	.76
Blood meal	91.5	3,642	.75	.69
Meat meal	91.0	3,542	.76	.69
Herring meal	91.0	3,711	.73	.66
Cod meal	91.0	3,597	.75	.68

As a further illustration, table 2 shows the results obtained in the evaluation of some of the most important poultry feedstuffs.

For the Swedish feedstuffs, which are now being investigated as poultry feeds, the author has made the evaluation by the method here given. When these feedstuffs were arranged according to the amount of fiber in the dry matter, the nutritive value given in table 3 was obtained.

With increasing percentage of fiber in the dry matter, the nutritive value for poultry thus decreases very rapidly. With an average of 32.5 percent of fiber in the dry matter, the organic substance has only 30.9 percent of the value it would have if it included no fiber. This result agrees very well with what is to be expected from the ability of chickens to digest the organic substance. Thus, the method of evaluating feedstuffs here given can become of great practical importance. In order for this to be the case, norms for nutritive requirements must be given which are based on this feed unit. Such norms have therefore been worked out by the author (1937).

TABLE 3.—*Nutritive value of Swedish feedstuffs being investigated as poultry feeds*

Percentage of fiber in the dry matter	Dry matter per feed unit	Relative nutritive value of the dry matter
	Kilograms	
0	0.72	100.0
0.1-5.0	.83	87.0
5.1-10.0	.88	82.0
10.1-15.0	.99	72.7
15.1-20.0	1.09	66.2
20.1-25.0	1.37	52.5
25.1-30.0	1.83	39.6
30.1-35.0	2.32	30.9

For a bird with a weight of 2.0 kg, an average of 0.08 feed unit for each day is calculated for maintenance. The amount of this feed may be considered as proportional to the chicken's weight raised to the $\frac{5}{8}$ power. For growth, 1 feed unit is calculated to store 1,600 to 1,700 calories in the tissues. According to very inclusive examinations, there is used in egg laying 1 feed unit per kilogram of eggs, containing about 1,640 calories. In fattening, 1 feed unit is calculated to give, on an average, 0.25 kg of increase of weight with 1,600 to 1,700 calories.

SUMMARY

From the author's account of experiments on digestibility, it has been shown that chickens have nearly the same ability as ruminants to digest the organic matter in the feed exclusive of fiber. With an increasing percentage of fiber in the dry matter, the ability of chickens to utilize the nutrients in the feed decreases much more quickly than does that of ruminants. Therefore, the feed for chickens must be evaluated differently from that for ruminants. The evaluation of the feed for chickens ought not, for several reasons, to be based on the amount of net energy. Instead, it seems that the metabolizable energy in the feed might be used as a basis for the evaluation, whereby the digestible protein is estimated to contain 4.7 calories, the digestible fat 7.8 to 9.3 calories, and the digestible carbohydrates 3.8 calories of metabolizable energy per gram. Normal barley thus contains 2,712 metabolizable calories per kilogram, which amount is to be used as a feed unit for chickens. The nutritional need of chickens has then been expressed in this unit.

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REVIEW OF INVESTIGATIONS IN THE BUREAU OF ANIMAL INDUSTRY ON ENERGY AND GASEOUS METABOLISM OF THE DOMESTIC FOWL

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Since 1924 the Bureau of Animal Industry of the United States Department of Agriculture has been studying the energy and gaseous metabolism of the domestic fowl and of its developing embryo. All measurements of heat production and gaseous exchange were made with the aid of accurate respiration calorimeters. This paper presents, for the first time, a curve which shows the course of the energy metabolism from the beginning of incubation to the age of 51 weeks and reviews briefly the work that has been published thus far. This work includes that of Barott, Byerly, and

Pringle (1936)[1], Barott (1937)[2], and Barott and coworkers (1938)[3].

Curve 1 in figure 1 shows the intensity of metabolic activity, in calories per day per gram of weight, of the developing embryo, the growing chick, and the adult chicken. Curve 2 in figure 1 shows the relationship of weight to age of bird. In the case of the embryo, the weight includes that of the yolk sac and allantois. From these two curves the metabolism for any weight may be determined. Curve 1 shows flexures during prenatal life which, so far as the authors know, have never been shown previously. The points of flexure appear at what may be termed critical periods during prenatal growth.

Immediately after incubation begins, cell division in the blastoderm proceeds at an ever-increasing rate. The energy metabolism follows the same trend, increasing at such a rate that at the end of the second day it has reached a value of 165 calories per day per gram of weight. This value is not much less than the maximum value attained during the entire life cycle of the fowl. During the third day the energy metabolism is practically at its maximum value. At this time the central arterial system is fairly well established and circulation is being maintained by the heart. From the end of the third day to the beginning of the eighth day, during which time the embryo is taking definite form, there is a steady drop in metabolic activity so that during the eighth day it amounts to only 70 calories per day per gram of weight, or considerably less than half of the previous maximum. By the ninth day the contour of the embryo has become quite birdlike and from this time until the thirteenth day, at which time the body is covered with down and the nail structure appears, there is a steady rise in the metabolic rate to a value of 106 calories per day per gram of weight. From the sixteenth day to the nineteenth day there is another appreciable fall in metabolic rate. This period is one of the most critical during embryonic growth. There is a decided change in the respiratory mechanism of the embryo with the initiation of pulmonary respiration; the central nervous system also undergoes important changes. From the nineteenth day of incubation to approximately the fifteenth day after hatching there is a steady rise in the metabolic activity. About the fifteenth day after hatching the rate is approximately 176 calories per day per gram of weight. From this time the metabolic rate of the chicken falls rapidly and nearly uniformly until at 8 weeks of age it is approximately 65 percent of the value at 2 weeks. The rate continues to fall, though not so rapidly, and by the eighteenth week it is less than 50 percent of the rate at 2 weeks. From the eighteenth week to maturity the decrease in rate is so slow that at 1 year the metabolic rate is approximately 90 percent of that at 18 weeks.

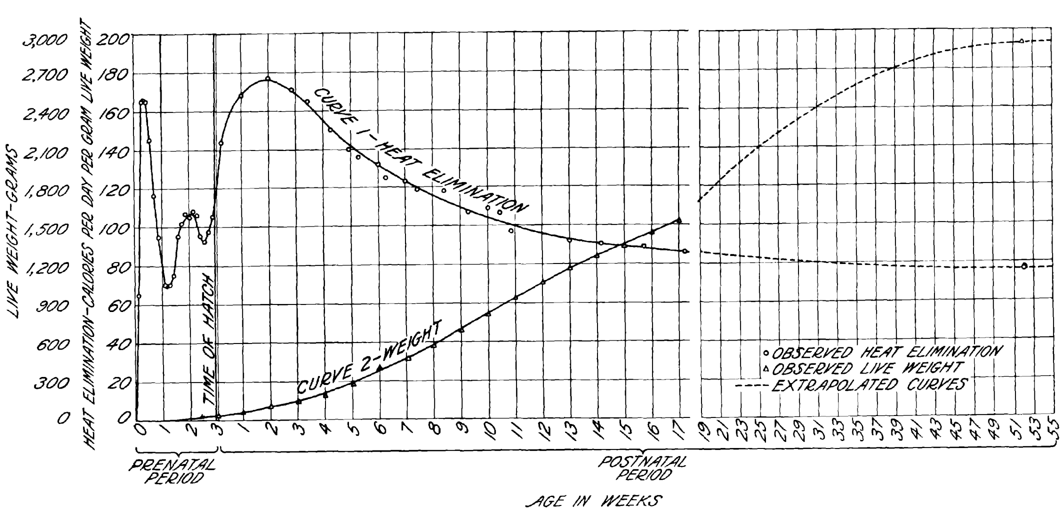

FIGURE 1.—Energy metabolism of the domestic fowl from the beginning of incubation to approximately 1 year of age. Values to the eighteenth week represent observations; broken lines represent extrapolated values.

EFFECT OF TEMPERATURE ON THE METABOLISM OF THE FOWL

Temperature has a decided effect on the heat elimination of the developing embryo, according

[1] BAROTT, H. G., BYERLY, T. C., and PRINGLE, E. M. Energy and gaseous metabolism of normal and deutectomized chicks between 10 hours and 100 hours of age. Jour. Nutrition 11 (3):191-210. 1936.

[2] BAROTT, H. G. Effect of temperature, humidity, and other factors on hatch of hens' eggs and on energy metabolism of chick embryos. U. S. Dept. Agr. Tech. Bull. 553. 1937.

[3] BAROTT, H. G., FRITZ, J. C., PRINGLE, E. M., and TITUS, H. W. Heat production and gaseous metabolism of young male chickens. Jour. Nutrition 15 (2):145-167. 1938.

to Barott (1937). Experiments over a range of temperature of 96° to 103.5° F. showed that the optimum temperature for development is 99.5° F. As the temperature is reduced below this figure the rate of heat elimination is retarded, and the greater the reduction the greater the retardation. Likewise, as the temperature is increased above this optimum the rate is accelerated. However, the time required for incubation is increased as the temperature is lowered and decreased as the temperature is raised, so that the total heat elimination for the whole incubation period for any temperature is practically the same.

The effect of temperature variation on the heat eliminations of chicks less than 4 days old was very decided, as shown by Barott, Byerly, and Pringle (1936). The minimum metabolism occurred at 96° F. and established that point as the critical temperature. An increase or decrease of 7° from the critical temperature caused about 15 percent of increase in metabolism. With decrease in temperature from 90° to 70° F., metabolism increased in proportion to environmental temperature until at 70° F. the energy output was twice as great as at 96° F. The chick was unable to compensate for temperatures below 70° F., and the heat production began to decrease again so that at temperatures below 70° F. the chick would become chilled and soon die.

The effect of temperature variation on the heat elimination of hens was not so decided as for young chicks. Preliminary experiments show that the critical temperature (minimum metabolism) for hens occurs at approximately 83° F. An increase or decrease in temperature of 13° caused about 10 percent of increase in metabolism. With a decrease in temperature from 70° F., the metabolism increased rapidly until at 55° F. it had increased about 35 percent over the value at 83° F.

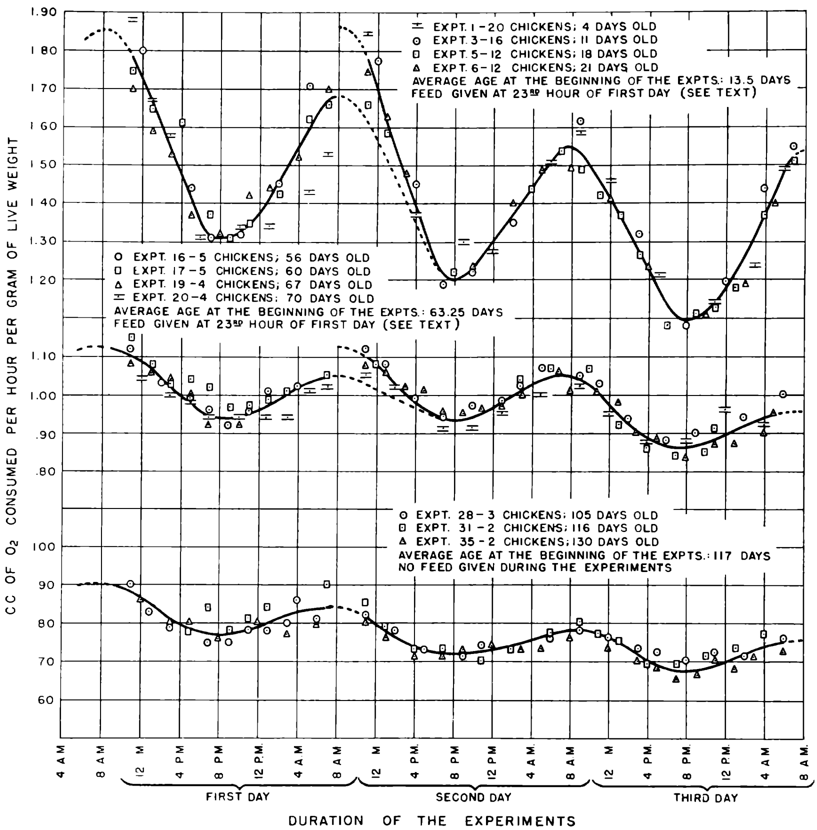

FIGURE 2.—Diurnal rhythm of the energy metabolism, as measured by the oxygen consumption, of fasting male chickens at different ages. Preliminary dotted lines show extrapolated values.

RESPIRATORY QUOTIENT

The respiratory quotient of the embryo at the beginning of incubation is approximately 1.00 but drops rapidly so that by the end of the first week it has reached a value of approximately 0.66, where it remains for the rest of the incubation period, according to Barott (1937). The respiratory quotient of chicks less than 4 days of age is approximately 0.71, as reported by Barott, Byerly, and Pringle (1936), and for chicks between 1 and 20 weeks of age, on adequate diet, it is 0.79, according to Barott and coworkers (1938). The respiratory quotient for basal metabolism (after 66 hours of fast) of the latter chicks is 0.72.

DIURNAL RHYTHM OF THE ENERGY METABOLISM

The course of the diurnal rhythm of the energy metabolism of Rhode Island Red chickens as it changes from hour to hour during a period of 24 hours was determined for oxygen consumption by Barott and coworkers (1938), inasmuch as the carbon dioxide and heat production were not measured at sufficiently frequent intervals to show the relatively smooth course of the change in metabolism.

That there is a very definite rhythm in the oxygen consumption of chickens is clearly shown in figure 2, in which data from several of the writers' experiments have been plotted. The marked break in each of the first two curves at the end of the first day was caused by the protein that was fed at this time.

The general effect of age on the diurnal rhythm is indicated in figure 2. The amplitude in the diurnal rhythm of the oxygen consumption for chicks 1 week old is about 12 percent of the oxygen consumption at 8 a. m. This means that an average maximum difference of about 24 percent was observed between the oxygen consumption at 8 a. m. and 8 p. m. After the age of 14 weeks was reached the amplitude of the diurnal rhythm tended to remain constant at a value of about 5.7 percent of the oxygen consumption at 8 a. m. This is equivalent to a difference of about 11.4 percent between the 8 a. m. and 8 p. m. values for oxygen consumption.

THERMOGENIC EFFECT OF CASEIN AND GELATIN

In experiments with Rhode Island Red chickens 11 to 18 weeks old, the procedure followed in determining the specific dynamic action of two proteins, casein and gelatin, is illustrated in figure 3. The upper curve in each of the two pairs is the observed oxygen consumption, and the lower curve represents the oxygen consumption which would have been observed if no protein had been fed. This curve was calculated from values obtained in independent experiments in which no protein was fed. These values were expressed as percentages of the oxygen consumption at the beginning of the fast.

The difference between the total quantity of oxygen actually consumed and the calculated quantity that would have been consumed had no protein been fed was considered as a measure of the thermogenic effect of the protein fed.

After the observed and computed oxygen consumption had been plotted, as shown in figure 3, the area between the two resulting curves was carefully measured with a polar planimeter. The resulting estimates of the specific dynamic action of casein and gelatin in a series of 16 experiments show that both the average initial increase in oxygen consumption and the average total increase per gram of nitrogen were greater for casein than for gelatin. If one uses 4.52 kg-cal. per liter as the average thermal equivalent of oxygen after casein or gelatin was fed, he finds that the average specific dynamic action of casein was 9.7 kg-cal. per gram of nitrogen and of gelatin 8.7 kg-cal. per gram of nitrogen. Apparently the specific dynamic action of casein and gelatin was not affected by age, although its duration was longer in the older chickens than in the younger ones.

Attention is directed to the fact that the specific dynamic action, its initial intensity, and its duration are not the same for casein and gelatin. Its duration was not so long for casein as for gelatin, but the initial oxygen consumption during the first 2 hours reached higher levels after casein was ingested than after gelatin was ingested. The difference in specific dynamic action between casein and gelatin is fairly large and, statistically, it is highly significant.

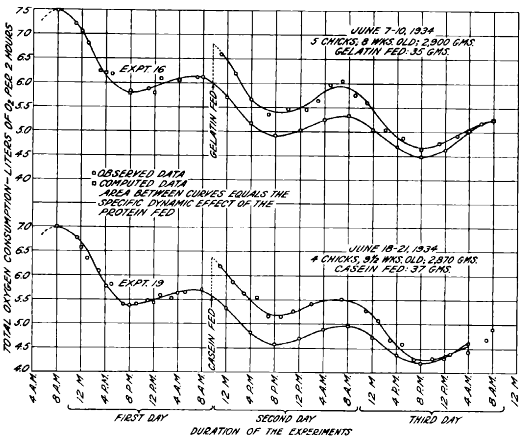

FIGURE 3.—Oxygen consumption as observed for one group of male chickens fed gelatin and another fed casein, and as computed for fasting chickens of the same age.

SUMMARY

Studies made at the Bureau of Animal Industry's Animal Husbandry Experiment Station, Beltsville, Md., on the energy and gaseous metabolism of the domestic fowl and on the developing embryo are reviewed. A previously unpublished graph shows the course of the metabolic activity from the beginning of incubation to the time the fowl is approximately 1 year old.

A study of the effect of temperature on the developing embryo shows that the temperature for optimum development is 99.5° F.

The minimum metabolism for baby chicks occurred at 96° F. and established that point as the critical temperature. As the temperature decreased the rate of metabolism increased until a temperature of 70° F. was reached. Preliminary experiments show that the critical temperature for the hen occurs at approximately 83° F.

The respiratory quotient of the embryo at the beginning of incubation is approximately 1.00. It drops rapidly to about 0.66, where it remains for the rest of the incubation period. The respiratory quotient of chicks less than 4 days old is approximately 0.71, and for chicks between 1 and 20 weeks of age it is 0.79. For the same chicks after 66 hours of fasting the respiratory quotient is 0.72.

The course and magnitude of the diurnal rhythm of the energy metabolism of the chicken as it changes from hour to hour for the 24 hours is shown by graphs.

The thermogenic effect of casein and gelatin when fed to chicks 11 to 18 weeks of age was investigated and found to be 9.7 kg-cal. per gram of nitrogen for casein and 8.7 kg-cal. for gelatin.

THE ROLE OF MANGANESE IN POULTRY NUTRITION

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Evidence that manganese is required by poultry was first reported by Wilgus, Norris, and Heuser (1936). They encountered an impure monocalcium phosphate which prevented rather than caused perosis. A study of the impurities present showed manganese to be primarily responsible. As little as 25 parts per million (or micrograms per gram) added to the perosis-producing diet prevented this avian bone deformity and improved growth. Further investigation showed that the basal diet contained only 10 p.p.m. of this element and that the perosis-preventing property of wheat germ, wheat middlings, and other common feedstuffs is closely associated with their manganese content. The effectiveness of manganese in controlling perosis was confirmed by Gallup and Norris (1937a), Heller and Penquite (1937), Lyons, Insko, and Martin (1938), Wiese, Elvehjem, Hart, and Halpin (1938a), Schaible, Bandemer, and Davidson (1938), and others. Simultaneous with the report of Wilgus and associates (1936), Sherwood and Fraps (1936) presented evidence on the inorganic nature of the perosis-preventing factor in wheat gray shorts.

Further confirmation of the correlation between the manganese content of feedstuffs and their perosis-preventing action was presented by Schaible and associates (1938). In the manganese analysis of about 500 samples of feedstuffs, they found the grains to be relatively low in this element. In these feedstuffs the manganese was concentrated in the outer portions of the kernels. Meat scrap, fish meal, dried milk, and bonemeal were also very low in manganese. Limestone particularly, and oystershell and clamshell were frequently high. Green feeds were extremely variable. Variations in the feeds were influenced by differences in maturity, in soil reaction, and in soil manganese. The results of these investigators help to account for the preventive action of oat feed first observed by Hunter, Dutcher, and Knandel (1931), of rice bran reported by Titus and Ginn (1931), of wheat germ reported by Branion (1933), and of wheat shorts or middlings reported by Sherwood and Couch (1933).

Since manganese is so essential in preventing perosis, it was not unexpected to find that a deficiency of it retards growth. This fact was noted by Wilgus, Norris, and Heuser (1937), Gallup and Norris (1937b), Van der Hoorn, Branion, and Graham (1938), Insko, Lyons, and Martin (1938a), and others. Gallup and Norris (1939a) found that the stunting on low-manganese diets was not entirely a result of perosis, since even the chicks which were not crippled on such diets failed to grow normally. Van der Hoorn and coworkers (1938) reported that this element was essential for the maintenance of chicks. Caskey and Norris (1938) found that it was essential for maintenance of body weight in laying hens.

A deficiency of manganese (5.5 to 13 p.p.m.) in the diet of hens was found by Lyons and Insko (1937), Gallup and Norris (1937b, 1939b), and Caskey and Norris (1938) to result in subnormal hatchability, characterized by high embryonic mortality during the last few days of incubation. Typical symptoms of nutritional chondrodystrophy were found in these embryos by Lyons and Insko (1937). These symptoms included shortening and thickening of wing and leg bones, parrot beak, globular head, edema of the atlas joint, protruding abdomen, and retarded growth of down and body. These workers and Caskey and Norris (1938, 1939) also found that chicks from certain hens on the deficient diet suffer from head retractions, extreme nervousness, and head tremors. Improved hatchability and normal embryos were obtained by Lyons and Insko (1937) by increasing the manganese to 45.5 p.p.m. or by injecting 0.03 mg into the albumen of the egg. Caskey and Norris[1] found that between 35 and 50 p.p.m. of manganese in the diet sufficed for good hatchability. Schaible and coworkers (1938) obtained good hatchability on 39 p.p.m.

The manganese content of the eggs and embryos was shown by Lyons and Insko (1937) and Gallup and Norris (1937b, 1939b) to be closely related to the level in the dams' diet. This finding is in

[1] Unpublished results.

accord with the data of Vecchi (1933). Gallup and Norris (1939b) observed that chicks which pipped but failed to hatch from eggs produced by hens fed the deficient diets contained less of this element than those which hatched, indicating congenital debility, as found by Daniels and Everson in rats (1935). In general, chicks containing less than 0.005 mg in the body proper failed to hatch. Those chicks that hatched from eggs produced on the deficient diet were actually more resistant to perosis during growth than those from eggs produced on the high manganese diets, indicating that they hatched because of an inherent ability to assimilate or metabolize this element more efficiently. These chicks also stored more dietary manganese in the first 5 days of life. A low initial reserve of manganese in chicks is thus not correlated with perosis.

Manganese has also been shown by Gallup and Norris (1937b, 1939b) and Caskey and Norris (1938) to be essential for egg production. Production on deficient levels was as low as half that on adequate levels. Lyons and Insko (1937) did not report this effect. Caskey and Norris (1938) found that the breaking strength of eggs produced on a diet containing 13 p.p.m. of manganese was 6.6 pounds, whereas that of eggs produced on a diet containing 100 p.p.m. was 9.3 pounds. Eggshell ash was correlated with breaking strength. Gallup and Norris (1939b) found that hens were not adversely affected when fed as much as 1,000 p.p.m. of manganese.

The quantity of manganese required by chicks for the prevention of perosis and for normal growth was reported by Gallup and Norris (1937a, 1939a) to be about 30 p.p.m. for their strain of White Leghorns and about 50 p.p.m. for their New Hampshires. Insko and associates (1938b) report a minimum of 35 p.p.m. for their White Leghorns, and Schaible and coworkers (1938) found 41 p.p.m. to be sufficient for excellent results with their Barred Plymouth Rocks.

The tolerance of poultry for manganese appears to be relatively high. Levels of as much as 1,000 and 646 p.p.m. were found to have no detrimental effect by Gallup and Norris (1937a, 1939a) and Insko and coworkers (1938b), respectively. Heller and Penquite (1937) found 4,800 p.p.m. to be highly toxic. Van der Hoorn and associates (1938) reported some retardation of growth at levels exceeding 300 p.p.m., and the inhibition of normal barring and feather growth at a level of about 600 p.p.m. Schaible and associates (1938) also found some retardation in growth at levels exceeding those essential to control perosis. These widely conflicting results suggest that manganese per se is not directly involved in the toxic effect at the intermediate levels.

The requirement for manganese necessarily depends on numerous factors. Variations in breed and even strain requirements have been reported by Gallup and Norris (1939a), who suggested, as an explanation, the genetic variations in susceptibility to perosis reported by Serfontein and Payne (1927). The few early cases of perosis found to develop on levels of manganese as high as 1,000 p.p.m. were shown by Gallup and Norris (1939a) to result probably from an inherent inability of individuals to metabolize manganese rather than from an inadequate supply in the egg or feed. Differences in availability of manganese from various sources also strongly influence requirements. No differences in availability among the carbonate, dioxide, chloride, sulphate, or permanganate salts were noted by Gallup and Norris (1937a, 1939a) or by Schaible and coworkers (1938). Dissolving several of these salts in the drinking water did not enhance their effects. The latter workers also found no difference between these salts and the oxide ores—manganite, pyrolusite, hematite, psilomelane, and hausmannite. However, they did find a carbonate ore—rhodochrosite—and a silicate ore—rhodonite—to be relatively unavailable.

It was suggested by Heller and Penquite (1937) that manganese was not the only preventive of perosis, since rice bran was more effective than its ash. Later, Wiese and associates (1938a) postulated an organic preventive factor effective alone or with manganese, since they found some apparent destruction of the preventive property of rice bran by autoclaving 20 hours at 120° C. In a subsequent report Wiese, Johnson, Elvehjem, and Hart (1938b) presented evidence indicating that the organic factor functioning in the prevention of perosis was inositol. Caskey and Norris,[2] on the other hand, found that rice bran and wheat middlings, when autoclaved 24 hours at 120° C., were just as effective in preventing perosis as the unautoclaved feedstuffs. Furthermore, Sherwood and Fraps (1937) were able to account for all the preventive property of wheat gray shorts in an equivalent amount of ash. No explanation can be given at the present time for these discrepancies in results except the possibility that they are due to differences in the composition of the experimental diets used.

Manganese, when injected, is more effective in preventing perosis than when supplied in the diet. Lyons and associates (1938), Schaible and associates (1938), Caskey and Norris (1938), and Wiese and associates (1938b) found that the injection of manganese in quantities approximately equivalent to 6 to 10 p.p.m. of the diet was effective in preventing perosis. These quantities are much less than the 25 to 40 p.p.m. needed when supplied in the diet. From these results it appears that only about 25 percent of the manganese in the diet is available at ordinary levels of calcium and phosphorus.

Caskey and Norris (1938) showed that injected manganese was completely effective in preventing perosis, whereas manganese supplied orally was not, and that excess calcium and phosphorus in the diet increased the requirement for manganese. Wilgus and Patton (1939) found that freshly pre-

[2] Unpublished results.

cipitated calcium phosphate renders manganese insoluble in vitro. When White Leghorn pullets were fed a diet containing about 12 p.p.m. of manganese, 1.1 percent of calcium, and 0.7 percent of phosphorus, 50 percent of the manganese in the small intestines of the pullets was diffusible. When the quantity of manganese in the diet was increased to 62 p.p.m., 60 percent of this element was diffusible. Increasing the manganese in the diet to 62 p.p.m. and the calcium and phosphorus to about 2.2 and 1.7 percent, respectively, reduced the diffusible manganese in the small intestines to 20 percent. Since Schaible, Bandemer, and Moore (1935) showed that the percentage of insoluble calcium and phosphorus in the intestine increases with a greater concentration of these elements in the diet, it therefore appears that these elements directly affect the availability of manganese. Schaible[3] has subsequently found that calcium carbonate, oystershell, tricalcium phosphate, and bonemeal remove manganese from solution, thereby substantiating the results of Wilgus and Patton. These last-mentioned investigators (1939) also showed that ferric hydroxide would render manganese insoluble and thus explained their finding that as little as 0.17 percent of ferric citrate in the diet aggravated perosis.

The mode of action of manganese in the body has never been explained. Richards (1930), Schaible and coworkers (1938), and Gallup and Norris (1939c) have found it to be more highly concentrated in the liver and kidney, the quantity being roughly proportional to that in the diet. The extensive shortening, thickening, and twisting of certain bones in the body on low manganese diets are well known. The shortening and thickening have been observed in the long bones of the wings as well as of the legs of chicks by Gallup and Norris (1938) and Caskey, Gallup, and Norris (1939). It has also been observed by Lyons and Insko (1937) in the leg and wing bones of embryos from dams on a low manganese diet. Schaible and coworkers (1938) failed to find any connection between perosis and crooked breastbones. Caskey and associates (1939) found no changes in body composition but obtained a significant reduction in bone ash in chicks on a manganese-deficient diet. The manganese content of the bones was reported to be 0.60 p.p.m. by Gallup and Norris (1938) and 0.34 p.p.m. by Schaible and coworkers (1938). On an adequate diet the former investigators found 2.00 p.p.m. of manganese in the bones, whereas the latter found 1.60 p.p.m. Although this element is essential for normal bone formation, these small concentrations in the bone would seem to indicate that it is not important as a part of bone per se but rather is catalytic in nature.

This possibility has received support from the report of Wiese and coworkers (1938b) that the blood phosphatase of chicks on a low manganese diet was depressed from 15.9–51.3 units per 100 cc to 2.1–3.1 units, whereas the bone phosphatase was depressed from 8.5–10.0 units per gram to 3.6–7.7 units. Also, Thannhauser and coworkers (1937) observed that manganese increases the activity of a serum phosphatase. Although Wiese and associates (1938b) reported a slightly lower blood-ester phosphorus, this did not appear low enough to account for the marked drop in serum phosphatase. They also reported that the injection of inositol completely protected against perosis at dietary levels of calcium, phosphorus, and manganese, which alone failed to protect. The injection was followed by an increase in serum-ester phosphorus and in blood phosphatase. This work should stimulate further investigation of this problem.

[3] Personal communication to the authors.

SUMMARY

Manganese deficiency in poultry has been reported to result in abnormal bone development (perosis), nutritional chondrodystrophy, ataxia, inferior growth, failure to maintain weight, lowered egg production, decreased hatchability, reduced egg-breaking strength and eggshell ash, and lower concentrations of manganese in the egg, the embryo, the bones, and certain organs of the body.

The minimum quantity of manganese required in chick diets was found, because of breed differences, to vary between 30 and 50 parts per million. The quantity required by hens appeared to be about 40 to 50 p.p.m., but more work needs to be done to determine this. Diets containing 1,000 p.p.m. of manganese were not found to be toxic.

The availability of manganese is influenced by the source of manganese and by the quantity of calcium, phosphorus, and iron in the diet. Smaller quantities of manganese are required to prevent perosis when injected than when supplied orally. Injected manganese was completely effective in preventing perosis at high dietary levels of calcium and phosphorus, whereas manganese supplied orally was not. Blood and bone phosphatase and ester phosphorus are depressed by a deficiency of manganese.

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NECESSITY FOR AN ORGANIC DIETARY FACTOR AND FOR INSOLUBLE GRIT IN THE DEVELOPMENT OF THE GIZZARD LINING IN CHICKS[1]

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THE ANTI-GIZZARD-EROSION FACTOR

The occurrence in young chicks of crater lesions of the gizzard lining was reported in 1933 by Holst and Halbrook (*7*),[3] and in 1934 by Dam (*6*), and was ascribed to a dietary deficiency. We first became interested in these lesions on observing that they complicated experiments in which purified rations were fed (*4*). Work was undertaken on the nature of the deficiency and the occurrence and properties of the dietary factor involved. These studies soon received further impetus from reports that similar lesions occurred under practical conditions, particularly in battery-brooder chicks.

The lesions occur in the noncellular lining of the gizzard, and only rarely, when the condition is very severe, does the underlying mucosa show macroscopic changes. The area around the openings which communicate with the proventriculus and duodenum is the first to be affected, but the entire lining may become involved, in which case the number of lesions is very large. Individual lesions vary greatly in size but are seldom more than 3 or 4 millimeters in circumference.

As stated previously, gizzard lesions were first observed in chicks fed purified rations. The composition of two of the rations used in these experiments is given in table 1. The brewer's yeast and liver extract are included to supply the various members of the vitamin-B complex. In ration 454 the cod-liver oil serves as a source of vitamins A and D. In a ration of this kind it is necessary to add some crude material, such as the 10 percent of peanuts, to supply various unknown essentials not furnished by small quantities of yeast and liver extract. In later experiments some difficulty due to variability in the peanuts was encountered, and a change was made in ration 465. Alfalfa leaf meal replaces the peanuts in this ration. Oleum percomorphum is administered as a source of vitamins A and D, and additional vitamin D is supplied by ultraviolet irradiation.

In the earlier stages of this work a number of plant and animal materials were assayed for their content of the preventive factor, which we have designated the anti-gizzard-erosion factor. A summary of the results of these experiments and of other more recent studies is as follows: Good sources of the anti-gizzard-erosion factor are cartilage, pork lung, pork liver, and pork kidney. Intermediate sources are oats, wheat bran, wheat

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

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[3] Italicized numerals in parentheses refer to Literature Cited, p. 176.

middlings, whole wheat, and barley. Poor sources are corn, alfalfa, wheat seedlings, peanuts, wheat-germ oil, and soybean oil. The good and intermediate sources are mentioned in their approximate order of effectiveness.

It should be emphasized that, although more or less purified rations have been used in the study of this deficiency, it frequently occurs in chicks fed practical rations, particularly if such rations contain very large quantities of corn. The preeminence of oats among the cereal sources of this factor suggested experiments to determine the relative potency of whole oats, oat groats, and rolled oats. The Quaker Oats Company very kindly furnished samples obtained from the same original lot of oats. They were assayed and found to be of approximately equal potency.

That the factor involved is organic in nature was first demonstrated by heat treatment of grains; the factor was destroyed either by autoclaving or by dry heat. Experiments on the properties of the anti-gizzard-erosion factor showed it to be insoluble in fat solvents, on which point our results are in disagreement with those of Almquist and Stokstad (*2*), who have found hexane extracts of alfalfa and wheat bran to be potent. The factor as it existed in lung appeared to be associated with the connective-tissue proteins, and this fact, together with the effectiveness of cartilage, led to experiments with chondroitin, which is a constituent of connective tissues and which has been used in the treatment of stomach ulcer in humans. Typical results with some chondroitin preparations are given in table 2. The crude chondroitin was a mixture of chondroitin and chondroitin sulphuric acid with some protein and mineral impurity. The calcium salt contained the salts of these two compounds but was free of protein and relatively free of mineral impurities. The data in table 2 constitute proof of the effectiveness of these chondroitin preparations. The question then arises as to whether this activity is due to an impurity or whether it can be associated with a portion of the chondroitin molecule. The evidence on this question is incomplete but may be stated briefly as follows: The protein-free calcium salts and the fat-solvent extracted chondroitin both were more potent than the crude chondroitin, thus ruling out two classes of impurities. As for fractions of the chondroitin molecule, there are two that required consideration, namely, chondrosamine and glucuronic acid. The former may be excluded on the basis of the data in table 2. The latter has not been adequately tested, but preliminary results with an aldobionic acid preparation from gum arabic indicate that this acid is active. Since it is a combination of glucuronic acid and galactose, and since galactose has been shown to be without effect in preventing gizzard erosion, this preliminary evidence points to the possibility that glucuronic acid may be the effective compound. The effectiveness of the aldobionic acid preparation is also of interest as offering a possible explanation of the potency of oats and wheat bran. The activity of chondroitin does not provide such an explanation since it has been found only in animal tissues.

TABLE 1.—*Composition of rations*

Ingredients	Ration 454	Ration 465[1]
	Percent	*Percent*
Dextrinized starch	....	64
Dextrinized starch, heated to 120° C. for 24 hours	61	....
Casein, heated to 120° C. for 24 hours	18	....
Reprecipitated casein	....	18
Salts I	5	5
Brewer's yeast	2	1
Liver extract	2	2
•Dried peanuts	10	....
Alfalfa leaf meal	....	10
Cod-liver oil	2	....
Oleum percomorphum	....	(2)

[1] All chicks on this ration were irradiated with quartz-mercury vapor lamp 15 minutes per week.
[2] 10 mg per week.

TABLE 2.—*Effectiveness of various supplements in preventing gizzard erosion*

Supplement to ration 465	Chicks with indicated degree of gizzard lesions		
	None or slight	Marked	Severe
	Number	*Number*	*Number*
None	2	8	4
10 percent cartilage	13	0	0
3 percent crude chondroitin	6	2	0
5 percent crude chondroitin	16	3	0
Hexane extracted chondroitin (5 percent)	6	0	0
3 percent purified Ca chondroitin salt	6	0	0
2 percent chondrosamine	2	3	1

Discussion of the chemistry of the anti-gizzard-erosion factor would not be complete without reference to the recent report by Almquist (*1*) that gizzard lesions are prevented by bile, bile salts, and cholic acid. We have confirmed these findings but as yet have no evidence on which to base an explanation for the activity of two such dissimilar compounds as chondroitin and cholic acid.

Because of the fact that day-old chicks frequently have typical crater lesions of the gizzard lining, the question was raised as to whether the incidence of these lesions was related to the amount of anti-gizzard-erosion factor in the hen's ration. Investigation revealed the fact that gizzard lesions were fully as common among chicks from hens fed oats as the only grain as among those from hens receiving no other grain but corn.

THE FUNCTION OF GRIT

At one stage of our investigations on the anti-gizzard-erosion factor, we encountered a serious obstacle in the development of a second type of abnormality characterized by a very considerable thickening or swelling of the gizzard lining (*5*). Such linings were lighter in color, softer, and more conspicuously ridged than the normal. There seemed to be no correlation between the occurrence of this condition and of gizzard erosion. In attempts to prevent swelling of the lining, various dietary supplements were tried but without success until it was observed that chicks receiving an ample supply of grit were not affected by this abnormality. Further experiments showed that the swelling could be prevented by the addition of 5 percent of granite grit to the ration or by feeding a coarsely ground ration. Typical results are presented in table 3. Ration 360 contained 80 percent of oat groats, 15 percent of heated casein, and 1 percent each of NaCl, $CaCO_3$, $Ca_3(PO_4)_2$, baker's yeast, and cod-liver oil. Ration 456 was similar to ration 454 shown in table 1, except that yeast was substituted for the liver extract. The data obtained on this abnormality were not sufficiently extensive to permit an evaluation of its importance to the well-being of the chick. However, it was observed in a number of cases that groups receiving grit made better growth than groups receiving no grit. It is of interest to note that Wheeler (*10*) in 1903 and Platt and Stephenson (*9*) in 1935 reported that a ration containing grit gave better growth than the same ration without grit, and Jull (*8*) in 1915 obtained more economical gains when grit was supplied. Bethke and Kennard (*3*) in 1926 obtained better growth in the first few weeks of life when grit was fed, but the difference between the group receiving grit and the group receiving no grit disappeared between the fourteenth and twenty-eighth weeks. The results reported here pertain to chicks 5 weeks of age.

TABLE 3.—*Effect of various rations on the swelling of chick gizzard linings*

Basal ration No.	Supplement	Chicks with indicated degree of swelling: None or slight	Marked	Severe
		Number	*Number*	*Number*
360	None	3	2	4
360	5 percent granite grit	15	1	0
456	10 percent dried lung	1	0	3
456	10 percent dried lung and 5 percent granite grit	3	1	0
360	None (ration finely ground)	0	1	3
360	None (ration coarsely ground)	4	0	0
456	None (ration finely ground)	1	3	0
456	None (ration coarsely ground)	4	0	0

SUMMARY

Chicks fed purified rations composed of dextrin, reprecipitated casein, salt mixture, yeast, liver extract, and cod-liver oil in addition to small quantities of various natural food materials develop eroded or ulcerated gizzard linings. The characteristic lesions are craterlike and are scattered over the entire lining in severe cases. This condition can be prevented by including in the ration 30 percent of oats or of wheat bran, or 15 percent of pork lung, liver, or kidney, or 10 percent of cartilage. That the factor involved is organic in nature was first demonstrated by heat treatment of grains; the factor was destroyed either by autoclaving or by dry heat.

Among the grains, oats, wheat bran, and wheat middlings are the best sources, with whole wheat and barley occupying intermediate positions. Corn is a very poor source. Gizzard erosion occurs frequently under practical conditions, particularly when high levels of corn are fed.

Chemical studies of the factor as it occurs in lung tissue showed it to be associated with the connective-tissue proteins. This fact and its occurrence in cartilage led to experiments with chondroitin, which is a constituent of connective tissues and which has been used in the treatment of stomach ulcer in humans. It was found to be effective in preventing gizzard erosion when fed at a 3-percent level.

During the course of these experiments a second abnormality of the gizzard lining was observed, namely, a very marked thickening and softening usually affecting the entire lining. Observations were confined to chicks from 3 to 6 weeks old. The development of these thickened linings can be prevented by including 5 percent of granite grit in the ration. Coarse particles of other materials, if relatively indigestible, appear to perform the same function as grit.

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CEREALS IN THE FATTENING RATION[1]

By W. A. Maw, *Assistant Professor of Poultry Husbandry and Head of the Department of Poultry Husbandry, Macdonald College, Quebec, Canada*

The relative values of the four commonly used cereals—yellow corn, wheat, oats, and barley—as fattening feeds for chickens of varying ages are of economic interest to the producer of high-quality market-meat stock. The use of these cereals varies considerably, partly because of varying market values due to a large or small supply in a particular region and partly because of incomplete information as to their relative values as fattening feeds in producing the desired finish on stock. It is evident that the cereals differ in their composition and that such differences, especially in carbohydrate and fat contents, result in differences in feed consumption by the stock, gain according to the length of feeding period, fat content of the resulting carcasses, and the character of the fats produced.

The regular feeding practice is to supplement the cereal base with protein feeds, such as meat meal or milk products. Although supplementary protein feeds are necessary for satisfactory results, only the minimum requirements need be supplied.

The extent of the effect of the ration on the composition of the edible portion of the resulting carcass depends, in part, on the age of the stock and the previous feeding of such stock.

The rations used in the trials reported herein were made up from the same lot of cereal, in each case, except for hull-less oats and barley, which were from different lots. In all cases, except those mentioned as being the hull-less product, the cereal used was the ground whole cereal. All rations were supplemented with 6 percent of animal protein and 1 percent of salt.

The gains made for any given period of feeding were adjusted on the basis of the quantity of feed consumed.

GAIN AND FEEDING PERIOD

The effect of any ration on gain in body weight is closely related to the quantity of feed consumed for any given period of time. It is apparent that in feeding cereals so widely different in their physical nature (when ground and mixed with water) as corn, wheat, oats, and barley, the stock will react to them quite differently, thus influencing the feed intake for a period of time.

As reported[2] in the feeding of individual Leghorn broiler stock, the feeding of whole and hull-less oats and hull-less barley for a 7-day period resulted in significantly better gains than the feeding of corn or wheat; the barley group was intermediate. When fed for 14 days, however, the only cereal resulting in a significantly higher gain was the hull-less barley, this grain being better than the corn. In all other cases, the adjusted gains were very similar. Such results with broiler stock show the value of allowing sufficient time for the stock to become adjusted to the change in character and condition of the feed given. These results indicate that ground whole oats are as good as ground hull-less oats.

Similar results[3] are shown with trials in which mature Plymouth Rock roasters were individually fed for a 21-day period. In feeding the first 7 days, there was no significant difference in the adjusted gains between the wheat and oat groups, although wheat was significantly superior to corn or barley. When the feeding period was extended to 14 days, there were no significant differences among any of the four rations; but when extended to 21 days, the corn, wheat, and barley rations were equal and wheat and corn were superior to oats.

In a third trial,[4] in which Plymouth Rock roaster stock averaging approximately 5 pounds in weight was used, the individual and combined cereals

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[2] Maw, W. A. Scientific agriculture. The cereals in the fattening ration. II. The comparative values as rations for fattening Leghorn broilers. 1939. (In press.)

[3] Maw, W. A. Scientific agriculture. The cereals in the fattening ration. I. The comparative effect upon gains and composition of the carcasses with mature roasters. 1939. (In press.)

[4] Maw, W. A. Scientific agriculture. The cereals in the fattening ration. III. The relative values of the single and combined cereals as rations for immature roaster stock. 1939. (In press.)

were studied. In this trial the stock was group-fed for 21 days. The results, as to the effect on gain, showed that the single cereals appeared to be equal to the best combinations of two or three cereals, although wheat alone was significantly better than oats or barley singly, or any combination of the cereals. Wheat, however, was not significantly better than corn.

QUANTITY OF FAT IN EDIBLE MEAT

The quantity of fat produced by the feeding of the different cereals varies somewhat with all classes of stock fed. Corn is superior to the other three cereals in all respects: Amount in total edible meat and fat, the meat alone, the skin, and the abdominal fatty tissue. Wheat, oats, and barley follow in order, being similar in the percentage of fat in the total edible portion. When compared with the various combinations of the four cereals, certain combinations of two or three cereals were equal to or slightly better in some cases than wheat, oats, or barley, although no combination of two or three cereals was as good as corn alone. Certain combinations of cereals were inferior to any one of the single cereals.

DISTRIBUTION OF FAT IN THE EDIBLE PORTION

The author[5] was able to show an apparent effect of the cereal fed on the distribution of fat in the bodies of large roaster stock. Corn gave the best distribution of fat over the entire body with the largest quantity of fat deposited in the meat. Barley, oats, and wheat resulted in decreasingly less fat in the meat and increasingly more fat in the abdominal fat and skin.

In a later trial, with stock approximately 8 weeks younger in age, the effect of the single and combined cereals was studied. No apparent effect on the distribution of fat in the body was found. This finding indicates a possibility that the age of stock used may have a relationship to the effect of the ration fed on the deposition of fat in the body.

CHARACTER OF THE BODY FATS

The character of the fats in the body is influenced by the ration fed. Although the iodine value of the oils of the cereals, corn and barley, is approximately the same, these cereals produce widely different iodine values in the body fats. The fats of the different parts of the body also vary and are usually in the same trend with each part according to the cereal fed. The flesh fats have higher iodine values than the skin fats or the abdominal fatty tissue. The length of time that the cereal has been fed has a bearing on the ultimate character of the fat.

[5] MAW, W. A. Scientific agriculture 16, 2:77. The cereal grains and their use in poultry nutrition. II. Influence on live weight, gains and distribution of fat in fattening stock.

The results in feeding range-grown cockerels for 21 days showed that, in the flesh fats, corn resulted in an iodine value of 75.1, wheat 71.6, oats 73.2, and barley 68.1. The skin fats had iodine values of 72.4 in the birds fed corn, 71.3 in those fed wheat, 70.0 for the oats-fed group, and 66.2 for the barley. The fat of the abdominal fatty tissue of the birds fed the various grains had iodine values of 67.4 for corn, 65.6 for wheat, 63.2 for oats, and 56.5 for barley. With the exception of the iodine value of the flesh fat in the group fed oats, all other values were consistently lower in each part for the four groups, the corn-fed birds having the softest and the barley-fed birds the hardest fats, the groups fed wheat and oats being intermediate.

COLOR OF BODY FATS

The color of the body fats and skin of the stock fed the four cereals varies from deep yellow with yellow corn to a bluish-white with barley. Wheat gives a relatively white finish in skin color and a pinkish-white abdominal fat. Oats produce a light yellow skin and fat. The color of the shanks also varies, following closely the changes in the skin and fat colors. For comparison, the fat colors are expressed in milligrams of carotene per 100 grams of fat.

The intensity of the colors produced by the four cereals in mature roasters, fed 21 days, were as follows: Corn, 0.784; wheat, 0.476; oats, 0.420; barley, 0.280. In Leghorn broiler stock, fed 14 days, the values were less: Corn, 0.532; wheat, 0.280; oats, 0.252; barley, 0.280. The foregoing results showing less intensity of color, as expressed by the carotene content, in the broiler stock may be due to age or the relatively smaller quantity of fat developed in the body.

SUMMARY

The cereal grains—yellow corn, wheat, oats, and barley—as ground whole cereals for fattening purposes, vary in their effect on the gains made and the quantity and character of the fats produced in the body of the growing chicken. Such factors as the age of the stock being fed and the length of the feeding period have a bearing on the results obtained. The ground whole-oat ration was equal to ground hull-less oats in feeding broiler stock. With mature roaster stock, wheat and corn were found to be superior to oats in a 21-day feeding period, although on a 7-day period wheat and oats were of equal value, with wheat superior to corn or barley. The single cereals were equal to the best combinations of two or three cereals. Corn was superior to all other single or combined cereals in producing body fats. No significant differences in the distribution of fat in the body were found as between the single or combined cereals with 5-pound roaster stock. The character of the body fats was found to differ widely in iodine value and color.

PREFACE—TRENDS OF RESEARCH IN INCUBATION

By J. HOLMES MARTIN, *Director, Regional Poultry Research Laboratory, U. S. Department of Agriculture, East Lansing, Michigan, U. S. A.*

A glance at the Proceedings of the First World's Poultry Congress indicates little interest 20 years ago in research dealing with incubation. Extension circulars containing detailed instructions on "how to set a hen" were still being distributed and the small lamp-heated incubator was just giving way to the mammoth incubator.

The rapid increase in the proportion of eggs hatched artificially brought a realization to poultrymen, incubator manufacturers, and scientists of the great need for further research into the fundamentals of artificial incubation. Some of the most important accomplishments of incubation research have been the determination of the physical requirements (particularly heat, moisture and oxygen) of the developing embryo. The parallel technological developments in incubators, stimulated by experiment station research, were made possible by industrial engineering research. Although in the control of temperature, moisture and ventilation great strides have been made, further progress is possible. Classical embryology has contributed much to our knowledge of the morphology and histology of the developing embryo and indirectly has played an important part. The knowledge gained of the chemical and physical processes of the embryo is of great importance and should lead to still further important results.

The vital problems of incubation today are: (1) To increase the quality of chicks in regard to their physical constitution, adaptability to brooding environment, and resistance to light infections. This may be approached through a better understanding of the biological influences of incubation environment upon the post-incubation period. (2) To improve the economy of hatching through methods of early elimination of infertile eggs, more efficient selection of the most desirable hatching eggs, and perhaps commercial use of by-products of incubation—infertile eggs, eggshells, and dead embryos. (3) To develop more adequate criteria on which to base diagnoses of the difficulties frequently encountered in incubation. Considerable work on the underlying causes of embryo mortality has been done, but further information along this line is badly needed.

Under the best physical conditions for incubation the average hatch is still too small. The important discoveries concerning the relationship of vitamins and minerals to hatchability indicate that further studies along the line of embryo nutrition might prove fruitful in the solution of some of the problems of reduced hatchability. The importance of the improvement of the genetic constitution of the breeding stock is also apparent. Ninety percent hatchability for the season is not beyond realization, if optimum incubation environment is given eggs from hens bred for high hatchability and fed a well-balanced breeder ration.

So far as future research is concerned, it may not be possible to divide it into applied and theoretical, but at least of considerable practical importance is the determination of still further interactions and interrelationships between the various factors known to influence incubation. Perhaps the influence of differences in room conditions on the operation of the incubator would make it easier to understand why the apparent optimum conditions do not give the best results under some conditions. For instance, the optimum relative humidity seems to be slightly lower in the case of chicken eggs, and definitely lower in the case of turkey eggs in the western part of the United States. This can only mean that the requirements for best results are different in different areas, or that we do not have the full story. Much of the embryo mortality cannot be adequately accounted for on the basis of information now available.

The desired trend of future research in incubation is for embryologists, geneticists, and nutrition workers to study further the causes of developing embryos. This should assure more uniformity and greater economy of hatching.

INFLUENCE OF TEMPERATURE ON LENGTH OF ARTIFICIAL INCUBATION PERIOD OF GALLUS DOMESTICUS[1]

By E. W. HENDERSON,[2] *Research Professor, Poultry Husbandry, Iowa Agricultural Experiment Station, Ames, Iowa, U. S. A.*

INTRODUCTION

Evidence that temperature has a relative influence on the rate of early embryonic development of *Gallus domesticus* has been available since the time of Réaumur (1749). Edwards (1901) compiled an Index of Development for stages up to the blastodermal diameter of 7 mm. Henderson and Brody (1927), Henderson (1930), and Penquite (1938) studied the influence of temperature on embryonic development throughout the entire incubation period and found that the influence of temperature was greatest during the earlier stages of incubation. After the embryonic age of approximately 16 days, the chick seemed partially able to control its own temperature so that increases of temperature beyond 101.8° F. (38.8° C.) were futile.

In an attempt to influence embryonic development beyond the sixteenth day, Romanoff (1933) obtained a slight retardation of embryonic growth on the twentieth day at a temperature of 89.6° F. (32° C.) as compared with temperatures of 93.2° F. (34° C.) and 96.8° F. (36° C.). At 21 days the embryos in Romanoff's experiment at 32° C. weighed 32.35 grams and those at 34° C. weighed 33.96 grams. The difference between means may not be significant, for the means were obtained from four embryos and no measure of variability was given. At 40° C. Romanoff states that "growth of embryo at first was accelerated then completely arrested." His conclusions regarding acceleration do not seem warranted from his data, but considerable arrestment seems evident, at 104° F. (40° C.). The latter finding is in general agreement with the findings of Henderson (1930).

In applying the results of the influence of temperature on embryonic development to the time of hatching, Romanoff and Faber (1933) concluded that "hatching occurred one-half day or so earlier than usual at 'high' temperature." Later, Romanoff (1936) shows graphically a slight reduction (about one-half day) in time required to hatch when the eggs were exposed continuously to temperatures varying from a "normal" temperature of 37.5° to 39° C. The percentage of eggs that hatched varied from 14.5 at 95.9° F. (35.5° C.) to 7.79 at 104° F. (40° C.), and the highest (72 percent) was obtained at 100.4° F. (38° C.) in approximately 20 days.

Barott (1937) from extensive tests with precision methods obtained the highest percentage of hatch at 100° F. (37.78° C.).

In many of the attempts to find the optimum temperature for hatching, the eggs were subjected to the same temperatures throughout the incubation period. The effect of varying the temperature at different stages of embryonic development has not been completely investigated. It may be possible to reduce the period normally required for incubation by taking advantage of the findings of Henderson (1930) that embryonic growth is more susceptible to the temperature stimulus in the earlier than in the later stages of development. Since it has been shown by numerous investigators that embryonic mortality increases when the continuous temperature of 100.4° F. (38° C.) is exceeded, it seemed that a study of the effect of different temperature schedules might yield one that will give the maximum stimulation with a minimum mortality.

The embryonic mortality of chicks was found by Henderson (1930) to be 100 percent for 200 eggs by the end of the seventh day at a temperature of 108° F. in a sectional-type incubator (Prairie State). At 107° F. two embryos remained alive to the eighteenth day. It was assumed that the temperature of 100.4° F. (38° C.) is approximately normal, but a number of commercial incubators of the cabinet type are commonly operated at 99.75° F. (37.5° C.) for the first 18 days and at still lower temperatures after the eighteenth day.

EXPERIMENTAL

Objects

The objects of this investigation were to find a schedule of incubation temperatures that might reduce the length of the incubation period of chick embryos without increasing embryonic mortality, and to record the influence of extreme temperature on embryonic mortality.

General Procedure

The procedure in general consisted in the operation of incubators of identical type and size adjacent to one another in the same room at the same time of year. The eggs were of known production history and were distributed uniformly among the several incubators. In most cases one incubator was operated at the popular commercial temperature for comparative purposes. This procedure seemed desirable as it is well known that the hatchability of eggs from the same flock will vary with different seasons of the year. For this reason, it is not advisable to assume that results from one season of the year are comparable with those of another.

The incubators for the first set of trials in December 1932 and the second and third set of

[1] Journal Paper No. J575 of the Iowa Agricultural Experiment Station (Project 55).

[2] Dr. T. T. Milby, formerly research fellow at Iowa State College, assisted by operating incubators and recording data.

TABLE 1.—*Influence of temperature on length of incubation period of Gallus domesticus*

Trial No.	1								2						3						4					
Date started	December 30, 1932								January 31, 1933						March 1, 1933						October 2, 1937					
Lot No.	1		2		3		4		5		6		7		8		9		10		11		12		13	
Eggs set, number	217		217		217		217		207		208		207		164		159		167		192		192		192	
Infertile eggs, number	27		30		35		29		52		58		63		25		26		27		56		57		55	
Fertile eggs, number	190		187		182		188		155		150		144		139		135		140		136		135		137	
Day of incubation	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead	Temperature	Embryos dead
	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*	°F.	*Number*
1	100	...	107	...	107	...	105	...	104	...	105	...	105	...	104	...	101	...	103	...	99.5	...	104	...	104	...
2	100	...	106.5	...	106	79	104.5	64	104	19	105	32	105	27	103	6	101	8	103	9	99.5	13	103	10	103	6
3	100	...	107	156	105	...	[1]107-5	...	104	...	104	...	105	...	102	...	101	...	103	...	99	...	103	...	102	...
4	100	1	106.5	18	105	18	105	25	103	6	103	7	104	8	102	2	101	3	103	2	99.5	5	103	3	105	3
5	100	...	106	...	104	...	104	...	103	...	102	...	103	...	102	...	101	...	103	...	99.5	...	103	...	102	...
6	100	3	106	10	102	12	104	19	103	2	101	2	103	6	102	2	101	2	102	1	99	4	103	3	101.5	3
7	100	...	105	...	101	...	104	...	102	...	100	...	102	...	101	...	101	...	102	...	99.5	...	103	...	101	...
8	100	...	105	3	101	6	104	4	102	1	100	3	101.5	4	101	1	101	1	102	...	99.5	0	103	1	101	1
9	100	...	105	...	100	...	103	...	102	...	100	...	101	...	101	...	101	...	102	...	99	...	102	...	101	...
10	100	...	104	...	100	3	103	10	101	3	100	1	101	4	101	1	101	1	102	1	99.5	1	102	0	101	2
11	100	...	104	...	100	...	103	...	101	...	100	...	100	...	101	...	101	...	102	...	99.5	...	102	...	101	...
12	100	13	104	...	100	7	103	9	101	2	100	2	100	5	101	3	101	3	101	2	99.5	...	102	1	101	...
13	100	...	103	...	100	...	102	10	100	...	100	...	100	...	101	...	101	...	101	...	99.5	...	101.5	...	101	...
14	100	...	103	...	100	5	102	...	100	5	100	4	100	3	101	5	101	2	101	4	99.5	...	100.5	...	101	1
15	100	...	103	...	100	...	102	19	100	...	100	...	100	...	101	...	101	...	101	...	100.5	...	100	...	100.5	...
16	...	...	...	...	...	...	...	...	100	5	100	1	100	1	101	4	101	6	100	6	99.5	...	100	...	100.5	...
17	...	...	...	...	...	...	...	...	100	...	100	...	100	...	100	...	101	...	100	...	98.5	...	100	...	101	...
18	...	...	...	...	...	...	...	...	100	...	100	...	100	...	100	...	101	...	100	...	97.5	...	100	...	101	...
19	...	...	...	...	...	...	...	...	100	...	100	...	100	...	100	...	101	...	100	...	97	...	100	...	100.5	...
20	...	...	...	...	...	...	...	...	100	...	100	...	100	...	100	...	101	...	100	...	97	...	100	...	100	...
21	...	...	...	...	...	...	...	...	100	...	100	...	100	...	100	...	101	...	100	...	97	...	100	...	100	...
22	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	97	...	100	...	100	...
23	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	97	6	100	53	100	33
Pipped-number[2]	...		[3]		[3]		...		91		65		112		40		24		65		29		71		49	
Hatched No.	...		[3]		[3]		...		21		33		15		75		83		50		107		64		88	
Percent No.	...		[3]		[3]		...		14		22		10		53		62		35		78		47		64	
Mean time of hatching	...		[3]		[3]		...		20 Days 11.4 Hours		20 Days 10.8 Hours		20 Days 8.5 Hours		20 Days 0 Hours		20 Days 6.6 Hours		19 Days 22 Hours		21 Days 8 Hours		20 Days 3 Hours		20 Days 6 Hours	

[1] 107° for not more than 2 hours on this day.
[2] Not hatched.
[3] Not recorded.

trials in January and March 1933 consisted of four commercial cabinet-type machines of identical model with a capacity of about 1,100 eggs each. The incubators were heated by electricity and mechanically ventilated. They were operated in the same semibasement room during the same periods in such a manner that the only variable not anticipated by sampling was that of temperature. The relative humidity was approximately the same for all incubators. Temperature was recorded and eggs were turned three times

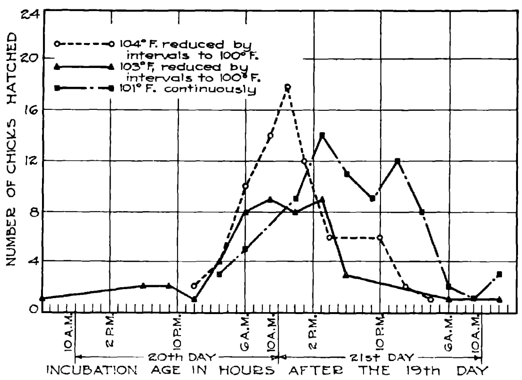

FIGURE 1.—Influence of temperature on the length of the incubation period of *Gallus domesticus* (trial 3).

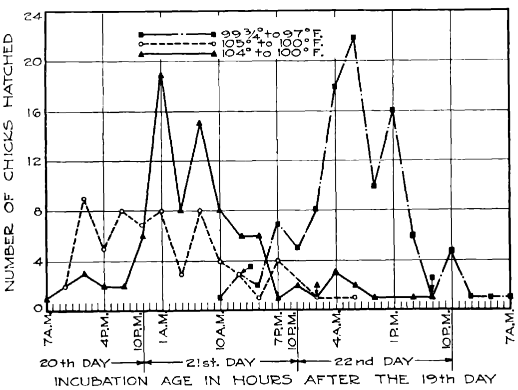

FIGURE 2.—Influence of temperature on the length of the incubation period of *Gallus domesticus* (trial 4).

daily. The number of dead embryos and the approximate age at death were estimated from an examination of the egg contents on the sixteenth day. The number of live embryos was estimated by the ordinary candling procedure.

Special Procedures

The first, or preliminary, trial consisted in the incubation of four groups or "sets" of 217 eggs each, of identical production history, at four temperature schedules beginning at 100°, 107°, 107°, and 105°, F., respectively, as indicated in table 1. This trial began December 30, 1932. Since the temperature schedules were known to be extreme for this type of incubator, comparison was made on the basis of the number of embryos alive on the sixteenth day. The detailed results are indicated in table 1.

The second trial consisted of three sets of approximately 200 eggs each at a temperature schedule beginning at 104°, 105°, and 105°, respectively. The "normal" incubator was omitted at this time, for results with it were generally well known and it was not expected that incubator No. 5, which was set at 104°, would prove to be greatly different from the normal. Results are indicated in table 1.

The third trial consisted of three sets of approximately 160 eggs each, incubated at three temperature schedules beginning at 104°, 101°, and 103°, respectively. The data are indicated in table 1 and figure 1. The fourth trial, made in 1937, consisted of three sets of 192 eggs each at initial temperatures ranging from 105°, 104°, and $99\frac{3}{4}$° for the first 24 hours. The temperatures were reduced as indicated in table 1. The results of trial 4 are given in table 1 and figure 2.

DISCUSSION

It seems from trial 1 that a high temperature (107° F.) at the early stages which is gradually reduced to 101° by the seventh day is not so detrimental as a temperature of 105°–104° F. continuously for the first 6 days. The sixth day was chosen for the change of temperature, for Henderson (1930) has shown that the rate of embryonic growth changes rather abruptly at that time. The distribution of estimated embryonic mortality by days is indicated in table 1. Apparently a temperature of 103° is too high for the sixth day. A temperature of 107°–105° continuously during the first week seems to be fatal to practically all chick embryos.

It was evident that the temperature schedules of the first trial were too high; therefore, no record was obtained of the possible hatching date of the few remaining live embryos. On the sixteenth day 173 were still alive in lot 1, none in lot 2, 52 in lot 3, and 28 in lot 4.

The hatching results from the second trial were disappointing in that few of the embryos hatched that were alive on the sixteenth day. Inconsistency is evident also in that a greater percentage of hatch (22 percent) was obtained at an initial temperature of 105° reduced about 1° by 1-day intervals to 100° than was obtained at an initial temperature of 104° reduced by 2-day intervals to 100°. The high temperature of 105° reduced by 2- and 1-day intervals killed more embryos the first 12 days than that of 104°, reduced by 3-day intervals.

A slight relationship between temperature and the length of time required to hatch is evident between the eggs incubated at a temperature of 105° (lot 7) reduced by intervals to 100° and those incubated at the other temperatures although there is less than 4 hours' difference between the means. None of the embryos hatched as early as expected. It is rather common practice among commercial hatchery operators to discard chicks that fail to hatch by the end of the twenty-second day, according to Townsley[3].

The fact that the percentage of hatch was low in all incubators may be partly explained by the fact that hatches are frequently poor in the winter.

The results of trial 2 suggest that extremely high temperatures reduce the time required to hatch, but the reduction was not so great as was expected. In trial 3 the embryos in lot 10, with an initial temperature of 103°, hatched in an average time of 19 days 22 hours as compared with 20 days and 6.6 hours required by those in lot 9, with an initial temperature of 101°, and 20 days 8.5 hours for those in lot 7, with an initial temperature of 105°, the most rapidly developing lot in trial 2. Greater variation in incubation time seemed possible since the popular commercial temperature is 1¼° F. lower than that of lot 9. The distribution of the number of embryos hatching at the different times is indicated in figure 1.

Although trials 2 and 3 may not be comparable because the eggs were produced at different times of the year, it is evident that the temperature schedule of lot 8 distinctly reduces the mean time required to hatch when this mean is compared with that of lot 9. The difference between means is highly significant. This reduction in time is accompanied by a slightly lower percentage of hatch (53 percent vs. 62 percent) but the difference in hatching percentage may not be statistically significant.

From trial 4 it seems more evident that a reduction in hatching time is accompanied by slightly increased embryonic mortality. The chicks in lot 13 hatched in an average time of 20 days 6 hours at the rate of 64 percent as compared with 21 days 8 hours required by the chicks in lot 11, which hatched at the rate of 78 percent. The reduction of more than 1 day in hatching time is accompanied by a reduction in hatching rate that is significant. The eggs in lot 13 were subjected accidentally to the abnormally high temperature of 108° F. for a few hours on the fourth day. This fact may have been partly responsible for the lower hatching rate of lot 13, but the temperature influence was not evidenced by a high mortality rate immediately. It does not seem logical that the effect of high temperatures may be delayed until near hatching time, but the results of lots 12 and 13 suggest this possibility.

If the periods of incubation of 19 days 22 hours required by the chicks in lot 10 and 20 days 6 hours in lot 13 are compared with the period required in commercial practice (22 days), a reduction of more than 1 day in the incubation period of chicks seems possible, but the reduction in time may be accompanied by a slightly lower percentage of hatch. The reduction in time required to hatch in trial 4 (lot 11 vs. lot 13) is greater than that in trial 3 (lot 8 vs. lot 9), but there is a slightly wider variation in embryonic mortality.

[3] Personal communication.

SUGGESTIONS FOR FUTURE INVESTIGATION

Although the results of this investigation support the hypothesis that the length of the incubation period of chick embryos can be reduced, the causes for the slightly increased embryonic mortality require further investigation. One of the factors that may account for the increased mortality is an increased rate of moisture loss at high temperatures. A study of the metabolic rate of individual eggs accompanied by gross anatomical and histological examinations of both living and dead embryos under the various conditions of incubation seems necessary for future investigations. Other possible factors are (1) the stage of embryonic development at the time the eggs are laid (2) the amount of retardation of development as a result of storage prior to incubation, and (3) the variable rate of development of embryos from individual hens and hens of certain genetic history.

Hutt and Pilkey (1930) have shown that the percentage of hatch is affected by the time of day at which eggs are laid and it seems logical that the length of time required by embryos to hatch may be affected by this factor. The use of multiple matings followed by appropriate statistical analyses of the data may permit the segregation of the various genetic factors.

SUMMARY

A reduction of at least 1 day in length of time that chicks of domestic fowl require to hatch seems possible from a study of the hatching time of 13 lots of eggs, totaling about 2,500, set at various temperature schedules. The temperature schedules were selected on the hypothesis that the chick embryo is most susceptible to temperature influences in its early stages of development. The average length of time required to hatch at initial temperatures of 104° F., reduced gradually to 100° by the sixteenth day, varied from 20 days with a hatch of 53 percent to 20 days 6 hours with a hatch of 64 percent. At a constant temperature of 101°, the chicks hatched in 20 days 6.6 hours at the rate of 62 percent. Chicks incubated at the temperature of 99.5° F. for the first 16 days, reduced to 97° F. on the eighteenth day, hatched in 21 days 8 hours at the rate of 78 percent. Another group, which was incubated at a temperature schedule of 104° F., reduced to 100° during the third week, hatched in 20 days 6 hours at the rate of 64 percent.

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EFFECT OF TEMPERATURE SHOCK ON DEVELOPMENT OF CHICK EMBRYO

By ALEXIS L. ROMANOFF, *Research Assistant Professor, Cornell University Agricultural Experiment Station, Ithaca, New York, U. S. A.*

It has been commonly accepted since the time of Réaumur (1749) and supported by the experiments of Prévost and Dumas (1825), Rauber (1884), Dareste (1891), Féré (1894), Kaestner (1895), and Edwards (1902) that at a low temperature the development of the chick is retarded, whereas at a higher temperature it is accelerated. Recently Henderson (1930), Romanoff and Faber (1933), and Kaufman (1934) presented further evidence that the influence of temperature is greatest in the early stages of growth and that it decreases with successive stages. Moreover, the data of Romanoff, Smith, and Sullivan (1938) definitely show that during the latter part of incubation both high and low temperatures slightly retard the embryonic development.

However, all these experiments were made largely on continuous or long exposures to high and low temperatures and do not reveal the degree of susceptibility of the embryo to such temperatures at various stages of incubation. Also nothing is known about the effect of temperature shock on the post-exposure development of the embryo. To throw some light on these theoretically as well as economically important questions, the present experiments were undertaken.

MATERIAL AND METHODS

To determine the effect of temperature shock on the development of the chick embryo, 2,050 eggs, in groups of 50 to 200, were exposed for 24 hours at various stages of incubation either to 41° C. (105.8° F.) or 29° C. (84.2° F.) in laboratory air-agitated electric incubators (Romanoff, 1932). There were two different experiments. In the one, a study was made of the changes in the degree of susceptibility of the embryo with age. In this study each group of eggs previously incubated for various lengths of time under normal conditions was exposed for 24 hours to an abnormal temperature and then examined immediately after exposure. The second experiment was a study of post-exposure development of the embryo. In this study groups of incubated eggs were exposed for 24 hours to an abnormal temperature at 0, 4, 8, 12, or 16 days of incubation and thereafter continued to incubate under normal conditions, a few eggs from each group being removed daily for examination.

EXPERIMENTAL RESULTS

First experiment

The results of the first experiment are presented in the upper half of figure 1. To show the relative susceptibility of the embryo to abnormally high and low temperatures, the data on the percentage of deviation in the wet weight of the embryos after exposure are plotted against the wet weight of unexposed (or normal) embryos of corresponding age, which is taken to equal 100 percent. From this graph it is evident that the effect of temperature is greatest in the early stages, the growth of the embryo being accelerated by high temperature and retarded by low temperature. The 3-day-old embryo, for example, after exposure to high temperature weighs about 40 percent more than the normal embryo, whereas the embryo of the same age exposed to low temperature weighs 80 percent less than the normal one. With the advancement of incubation the thermal effects are lessened, and from about the tenth day both high and low temperatures slightly inhibit the development.

These results are of great biological interest. They remarkably illustrate that the chicken embryo behaves as a cold-blooded animal only until the tenth day of incubation but not until the time of hatching, as was suggested by Pembrey, Gordon, and Warren (1894–95).

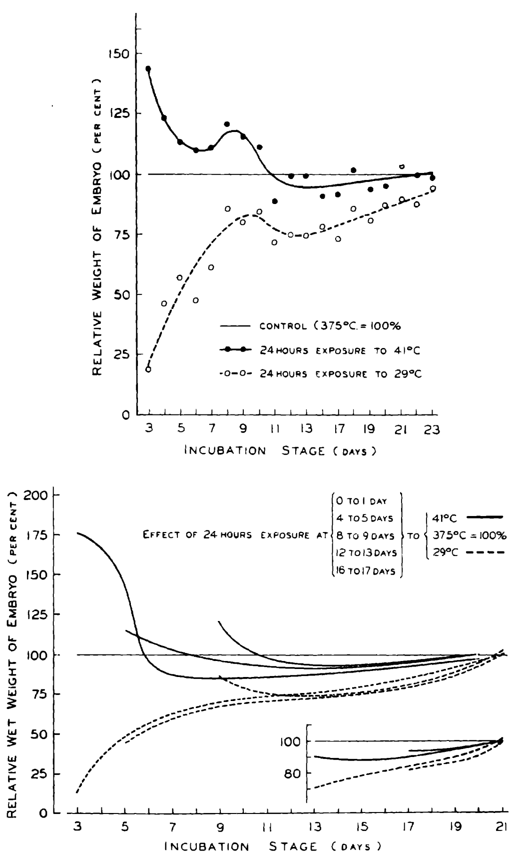

FIGURE 1.—Effect of temperature shock of 24 hours' exposure to 41° and 29° C. on the growth of the chick embryo. Upper half of the figure shows the immediate effect of 24 hours' exposure on the relative wet weight of the embryo; lower half shows the effect of 24 hours' exposure at 0, 4, 8, 12, and 16 days of incubation on the post-exposure relative growth of the embryo. The curves for 12 and 16 days of exposure are shown separately at the right lower portion of the figure.

Second experiment

The data of the second experiment are shown in the lower half of figure 1. To demonstrate the effect of exposure to high and low temperatures on the post-exposure embryonic development, the data on the percentage of deviation in the wet weight of the exposed embryo are plotted against the normal wet weight of the embryo, which is taken to equal 100 percent. The curves show that the growth of the embryo during all post-exposure periods is suppressed, even after the temporary acceleration in early stages by high temperature. This result leads to a delay in time of hatching, especially of those eggs that were exposed to low temperature during the early stages of incubation. Obviously, the physiological functions of the embryo were disturbed by temperature shock. The susceptibility of the embryo, as shown by total mortality, was greatest for the exposure to high temperature during the early periods and for the exposure to low temperature during the latter periods of incubation.

The practical significance of these results is that the exposure to any extreme temperature of short duration in the incubator will result in retardation in the growth of the embryo and delay in time of hatching. Moreover, any accidental overheating in the early stages or excessive cooling in the latter stages of incubation will result in heavy embryonic mortality.

From the results obtained, therefore, it is concluded that the chicken embryo reacts to temperature as a cold-blooded animal only during the early period of incubation and that a temperature shock inevitably retards further embryonic development, even after a temporary acceleration by the high temperature.

SUMMARY

To determine the specific effect of short exposures to extreme temperatures on the development of the chick embryo, 2,050 eggs were exposed for 24 hours at various stages of incubation either to 41° C. (105.8° F.) or to 29° C. (84.2° F.) in laboratory air-agitated electric incubators. In the study of changes in susceptibility of the embryo with age, the groups of eggs were exposed at all stages of incubation and examined immediately after the exposures. In the study of post-exposure development, the groups of eggs were exposed at 0, 4, 8, 12, and 16 days of incubation and examined daily thereafter until hatching.

The experimental data indicate that the effect of temperature is greatest in the early stages, the growth of the embryo being accelerated by high temperature and retarded by low temperature. With the advancement of incubation the temperature effects are lessened, and from about the tenth day both high and low temperatures slightly inhibit the development.

The growth of the embryo during all post-exposure periods is suppressed, even after the temporary acceleration by high temperature. This result leads to a delay in time of hatching. Physiological functions of the embryo are obviously disturbed by temperature shocks. The susceptibility of the embryos, as shown by total mortality, is greatest from the exposure to high temperature during the early periods and from the exposure to low temperature during the latter periods of incubation.

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AN EXPERIMENTAL STUDY ON THE EFFECTS OF STORAGE ON EMBRYONAL DEVELOPMENT OF HENS' EGGS

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It is a known fact that hatchability of hens' eggs decreases with increasing periods elapsing between the deposition of eggs and their incubation. The cause of the impaired embryo development was first examined by the author. In a former study (*4*)[1], it was ascertained that in eggs which had been held prior to incubation for 28 to 34 days the majority of embryos died during the first week of incubation. Those which survive are much smaller than the embryos of the same incubation age, developing in fresh-laid eggs. The percent rate of growth, however, is larger in the embryos growing in stored eggs and the smaller weight of embryos in these eggs was found to be due to delayed beginning of embryo growth. For example in fresh-laid eggs the body of the embryo is formed and growth begins after 36 hours of incubation, whereas in eggs which had been stored the primitive streak is the only structural feature observable at that time.

In continuation of this research, the author endeavored to elucidate the cause of the delayed development.

Warburg, Meyerhoff, Loeb, and Wasteneys, as quoted by Grossfeld (*3*), have shown that egg segmentation is accompanied by increase of respiratory exchanges. The role of SH-compounds in these processes and in cell segmentation was demonstrated by many investigators, such as Binet and Weller (*1*). On the other hand, Rapkine (*5*) found that a short passage of fertilized eggs of sea urchins through a weak solution of mercury sublimate totally checks cell division, but that it may be restored through the addition to the sea water of cysteine or thioglycolic acid. The arrest of cell divisions in his experiments is ascribed by Rapkine to blockade of SH-compounds by toxins.

It was thought possible that in stored eggs hydrogen peroxide hinders the normal processes of oxido-reduction and of cell division. This substance is normally formed in living cells but it is split up through the interaction of catalase. The content of catalase was found to decrease with age in plant grains, proportionately to their decreasing germinating power. Schmidt (*6*), Gracanin (*2*), and Dingenmans, according to Grossfeld (*3*), noticed much more catalase in fresh-laid eggs than in those which had been stored.

In the present experiments catalase content both of white and of yolk was determined in (a) 21 fresh eggs, 1 to 3 days old, (b) in 11 eggs, 10 days old, and (c) in 16 eggs after a month of storage. The eudiometric method was applied.

TABLE 1.—*Catalase content of eggs according to their age*

Cc of O_2 split up, at 25° C., by 3 g of—					
White of egg—			Yolk of egg—		
Fresh laid	After 10 days	After 30 days	Fresh laid	After 10 days	After 30 days
7.60 ±1.66	7.10 ±3.04	2.00 ± .66	0.25 ± .04	0.29 ± .03	0.40 ± .08

As shown in table 1, egg white contains much more catalase than egg yolk. No essential difference as to the content of the enzyme in the white was found between group (a) and (b). In group (c) a considerable decrease of catalase is observable in the white, whereas the yolk seems to become richer in this enzyme during storage.

[1] Italicized numerals in parentheses refer to Literature Cited, page 187.

Fresh-laid eggs from separate hens differ considerably as to their catalase content of their white, the range of variability of O_2 amounts split up by 3 g of white at 25° C. being from 0.6 to 29.9 cc per hour. When comparing the catalase content of eggs from the same hen, one to three days after being laid, and that after 30 days, there is, as a rule, a great decrease after storage. However, in the white of eggs of certain hens the catalase even after long storage was more abundant than on the average in fresh-laid eggs. For example, 3 g of white of the eggs, from a certain hen, which had been stored for 30 days were able to split up as much as 9.2 cc.

Embryonic development in stored eggs with high catalase content was compared with that of eggs which had been stored for the same time and were known to show low content of the enzyme. There was no difference as to embryo mortality between the two groups examined.

TABLE 2.—*Effect of injections of glutathion, M/500 and M/100, into stored eggs (incubation after 30 days of storage)*

Item	Injections made 10 to 14 days after egg was laid		Injections made more than 14 days after egg was laid		No injection
Substance injected...	Glutathion	H_2O_2	Glutathion	H_2O_2	....
Embryo mortality after 3 days (percent)..............	29.4	83.3	41.8	50.0	80.0
Normal development after 3 days (percent)..............	64.7	16.6	9.3	12.5	5.0

In order to study the possible role of hydrogen peroxide during aging of eggs, injections of the substance were made, before incubation, into eggs from 1 to 4 days after they were laid. An astonishing resistance of the germs toward the noxious influence of H_2O_2 was noticed. After injections of 0.2 cc of 0.3, 0.6, 1.0, 3.0 and 10.0 percent solutions respectively the development of the embryo and blood circulation were totally normal. Some foam was observed on the surface of the white, indicating its catalising activity. The results of these experiments do not solve the problem as to whether H_2O_2 induces delayed development or high mortality in stored eggs. They give evidence of the importance of the white as a factor protecting the germ against noxious agencies of the surrounding.

A further set of experiments was undertaken in order to examine the possibility of obviating the results of storage by injecting, into eggs, substances known to play a part during processes of oxido-reduction. The influence of glutathion was taken into consideration. Injections of this substance, M/500 and M/100 respectively, were made into eggs 10 to 14 days or more after they were laid and the development of the eggs after 30 days of storage was examined. From the results collected in table 2 it may be inferred that glutathion injected into eggs during the second week of storage had a certain protecting influence against the processes taking place during aging of eggs and impairing their vitality.

SUMMARY

The white of fresh-laid eggs contains large amounts of catalase. Its content is a distinguishing feature of eggs from separate hens and it has a wide range of variability. Far less enzyme was found in the yolk of fresh-laid eggs. The content of catalase in the white of eggs stored during 30 days is considerably reduced, the yolk of such eggs showing even larger amounts of enzyme than those of the yolk of fresh-laid eggs.

Great differences as to catalase content of the white was found between separate hens. No difference was noticed as to embryo mortality in stored eggs between groups with high and those with low content of catalase.

Normal embryo development was found in fresh-laid eggs injected before incubation, with 0.2 cc of H_2O_2 of 0.3, 0.6, 1.0, 3.0, and 10.0 percent solutions respectively.

Glutathion injections into eggs during the second week of storage seem to be able to reduce embryo mortality and increase the percent of normal development.

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DEVELOPMENT OF THE UNINCUBATED CHICK EMBRYO IN RELATION TO HATCHABILITY OF THE EGG

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INTRODUCTION

Since Stockard (1921) showed that embryos of a fish, Fundulus, when in pregastrulation stages of development under unfavorable environmental conditions were especially susceptible to injury leading to malformation and death, much interest has been aroused in a possible parallel condition being responsible for low hatchability in the eggs of birds. Patterson (1909) pointed out that bird's eggs are laid in varying stages of gastrulation, depending on the length of time elapsing between fertilization and oviposition. Results obtained by Hutt and Pilkey (1930) indicated that hen's eggs laid in the morning hatched significantly better than those laid in the afternoon. They suggested that the results were compatible with an expectation that more of the latter eggs than of the former would contain embryos in stages prior to or early in gastrulation. On the other hand, Funk (1934) found that eggs laid in the afternoon hatched better than those laid in the morning.

McNally and Byerly (1936) found that embryos in eggs laid in the early morning developed more somites after a period of incubation than embryos in eggs laid later in the day. They concluded that the former were in more advanced stages of development than the latter at the time of laying. This finding is in agreement with the report of Taylor and Gunns (1935) that the embryo in the first egg of a clutch is larger on the average than embryos in the other eggs of the clutch, the first egg of the clutch usually being laid earlier in the day than eggs in subsequent clutch positions. McNally and Byerly also produced evidence that the hatchability of eggs was influenced by the time interval between consecutively laid eggs. Maximum hatchability was observed when the time interval was 27 hours. With a shorter time interval a slight decrease in hatchability occurred, whereas hatchability decreased rapidly with an increasing time interval in excess of 27 hours. Possible differences in rate of production in the flocks used, therefore, might form a basis for explaining the apparently contradictory results of Hutt and Pilkey and of Funk.

Scott and Warren (1936) also found that with a longer time interval between successive eggs in a clutch there tended to be a relatively more advanced development of the embryo. However, they did not find any evidence for a longer oviducal retention of the first egg of the clutch, nor did they observe that embryos in the first eggs evidenced any greater development than those in the second eggs of a clutch.

Hays and Nicolaides (1934) studied the development of unincubated chick blastoderms from hens with characteristically high, medium, or low hatchability of eggs. They found the stage of development in freshly-laid eggs to be a characteristic of individual birds. Pregastrulation and early gastrulation stages were most commonly found in eggs from hens producing eggs of poor hatchability. Early gastrulation stages were characteristic of embryos from hens producing eggs of medium hatchability, and well-advanced gastrulation stages in embryos from hens exhibiting high hatchability of eggs. Taylor and Gunns (1935), however, have reported no correlation between size of the unincubated embryo and the hatchability of the eggs of the dam.

The present study was undertaken to determine some of the variables in the development and gastrulation of the unincubated chick embryo and their relation to the hatchability of the eggs of the dam.

EXPERIMENTAL METHODS

The same group of embryos which served as the basis for our previous report (1935) was examined. These embryos were derived from matings of hens selected for high, medium, and low hatchability of their eggs, or from matings of their pullet offspring, with a common male for each year of the test. Five years of such selection and mating produced, from 48 hens, 404 embryos, which, when fixed and sectioned, were found to be properly oriented so that median antero-posterior sections were available for study.

Measurements were made of size of the embryo as determined by its maximum diameter, of the extent of overgrowth, of the maximum depth of the embryo at the posterior zone of junction, of the amounts of tissue and of isolated entoderm, of the diameter of the area pellucida and the amount of this area not underlaid by entoderm, and of the number of yolk masses in the subgerminal cavity. The condition of the blastopore was also noted. The percentage of hatchability of fertile eggs of the dam was obtained from other eggs produced during the same weeks in which eggs for histological study were selected on arbitrarily predetermined days. The classification of dams with respect to hatchability of their eggs was made by following the procedure of Hays (1924).

RESULTS

Means for and differences among the hatchability groups of dams are given in table 1 for the various characters studied.

In the case of overgrowth, there was a significantly greater extent of development in the embryos from dams characterized by high hatchability of their eggs than in those from dams produced embryos with slightly but not significantly greater extent of overgrowth than those with medium hatchability, the correlation coefficient between overgrowth and hatchability

TABLE 1.—*Means and significance of differences for characters of embryos from dams classified according to hatchability of eggs*

Item	Hatchability classification: High (85 percent or more)	Hatchability classification: Medium (55-84 percent)	Hatchability classification: Low (54 percent or less)	Differences between—: High and medium	Differences between—: High and low	Differences between—: Medium and low
Number of dams	13	15	20	....	....	....
Number of embryos	108	140	156	....	....	....
Mean number of embryos per dam	8.3	9.3	7.8	....	....	....
Mean hatchability of fertile eggs of dams ... percent	90.9	71.8	31.0	....	....	....
Measurements of embryo:						
Maximum diameter millimeters	3.735 ± 0.059	3.591 ± 0.045	3.705 ± 0.050	0.144 ± 0.074	0.030 ± 0.077	−0.114 ± 0.067
Overgrowth ... millimeters	.321 ± .027	.229 ± .026	.258 ± .018	[1].092 ± .037	[2].063 ± .032	−.029 ± .032
Maximum depth at posterior zone of junction millimeters	.106 ± .004	.117 ± .004	.113 ± .004	[2]−.011 ± .006	−.007 ± .006	.004 ± .006
Tissue entoderm. millimeters	.635 ± .051	.734 ± .063	.649 ± .051	−.099 ± .081	−.014 ± .072	.085 ± .081
Isolated entoderm millimeters	.947 ± .060	.958 ± .077	.936 ± .043	−.011 ± .098	.011 ± .073	.022 ± .088
Total entoderm millimeters	1.582 ± .068	1.692 ± .052	1.585 ± .075	−.110 ± .084	−.003 ± .101	.107 ± .090
Diameter of area pellucida millimeters	2.101 ± .046	2.115 ± .046	2.182 ± .054	−.014 ± .065	−.081 ± .064	−.067 ± .064
Area pellucida not underlaid by entoderm ... millimeters	.519 ± .074	.423 ± .061	.629 ± .078	.096 ± .096	−.110 ± .109	[1]−.206 ± .099
Mean number of yolk masses per median section	18.069 ± 1.217	20.506 ± 1.761	17.490 ± 1.255	−2.437 ± 2.141	.579 ± 1.748	3.016 ± 2.162
Mean percentage of open blastopores	19.531 ± 4.602	25.506 ± 6.585	19.805 ± 4.515	−5.975 ± 8.034	−.274 ± 6.447	5.701 ± 7.984

[1] Significant differences.
[2] Differences approaching significance.

TABLE 2.—*Variance of embryonic characters*
[F at P of 0.05 = 1.10; F at P of 0.01 = 1.14]

Source of variance	Degrees of freedom	Maximum diameter		Overgrowth		Maximum depth at posterior zone of junction		Tissue entoderm		Isolated entoderm		Total entoderm		Diameter of area pellucida		Area pellucida not underlaid by entoderm		Yolk masses	
		Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square	Sum of squares	Mean square
Total	403	39.66	.....	10.955	.....	0.196	.....	73.774	.....	97.500	.....	63.164	.....	23.205	.....	78.231	.....	43640	.....
Between means of dams	47	17.01	.362	3.296	0.070	.078	0.0017	15.715	0.334	19.542	0.416	23.141	0.492	11.542	0.246	30.349	0.646	12578	268
Within means of of dams	356	22.65	.064	7.659	.022	.118	.0003	58.059	.163	77.958	.219	40.023	.112	11.663	.033	47.882	.135	31062	87
F		5.66		3.26		5.67		2.05		1.90		4.38		7.45		4.78		3.08	

characterized by medium hatchability. The difference between the dams exhibiting high and low hatchability of eggs approached significance. Since the dams showing low hatchability of eggs was computed. It was found to be 0.3158 ± 0.1313, a value approaching statistical significance. In a test for linearity, the zeta value of 0.1849 ± 0.1049 was obtained, which, in itself, is not significant. The correlation ratio was 0.5328, indicating that the extent of overgrowth, even when corrected for nonlinearity, does not serve as a highly accurate criterion of hatchability.

Embryos from dams producing eggs of low hatchability had a significantly greater extent of the area pellucida not underlaid by entoderm than embryos from dams whose eggs were of medium hatchability. Since the embryos from dams with high hatchability of eggs had an intermediate extent, it is difficult to assign any definite relation of this character to hatchability. In maximum depth of the embryo at the posterior zone of junction, the difference between the high- and medium-hatchability groups approached significance, but the trend was not uniform and the other differences were not significant.

Except for overgrowth, there was no definite evidence of any relation between the various characters of size or gastrulation of the unincubated chick embryos and the hatchability of eggs of the dam. It is not possible to postulate from our data that hatchability of eggs of the dam is closely related to the development of the embryo either with respect to size or to stage of gastrulation, as was found by Hays and Nicolaides.

In order to determine whether or not the embryonic characters observed varied characteristically according to the dam, analyses of variance were made. Table 2 presents the results obtained with 9 of the 10 measures employed. The condition of the blastopore, being either open or closed, was not amenable to such statistical treatment. It is evident that all characters measured showed significantly higher variability between the means of the dams than within the embryos of each dam. These characters of embryonic development are, therefore, valid expressions of the individuality of the dams. Whether or not they may be hereditarily determined cannot be concluded from the data available.[1]

SUMMARY

Data are presented on the following measures of gastrulation and development of unincubated embryos: Extent of overgrowth, maximum depth of the embryo at the posterior zone of junction, amounts of tissue entoderm and of isolated entoderm, diameter of the area pellucida and the amount of this area not underlaid by entoderm, number of yolk masses in the subgerminal cavity, and percentage of open blastopores.

These measurements were made on 404 embryos from 48 hens, which were divided into high-, medium-, and low-hatching groups, respectively, as follows: 108 embryos from 13 hens hatching more than 85 percent, 140 embryos from 15 hens hatching between 55 and 85 percent, and 156 embryos from 20 hens hatching less than 55 percent of fertile eggs.

With the exception of the amount of overgrowth, none of the characters were significantly different for the three hatchability groups. In the case of overgrowth, the high-hatchability group had a significantly greater extent of overgrowth than the medium. The difference between the high- and the low-hatchability groups was of borderline significance, the high group having the greater extent of overgrowth. A correlation of 0.3158 ± 0.1313 was found between amount of overgrowth and hatchability, the correlation ratio being 0.5328. The test for linearity yielded a zeta value of 0.1849 ± 0.1049.

The above characters of the gastrulation and early development of the embryo in the unincubated egg, although representing definite expressions of the individuality of the dam, do not appear to be intimately associated with a high potential hatchability of the egg. The degree of correlation between the amount of overgrowth and the percentage of fertile eggs is too low for purposes of accurate prediction of individual hatchability.

[1] The writers acknowledge with thanks statistical assistance provided by the W. P. A. under project number A. P. No. 465-03-3-209.

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EFFECT OF INTERIOR QUALITY OF EGGS ON THEIR HATCHABILITY

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INTRODUCTION

In the course of investigating the effect of heredity on the interior quality of eggs, particularly as measured by the albumen index, it became evident that there was a marked difference in the hatchability of eggs from individual hens. These differences suggested that there might be some relationship between hatchability and some measurements of egg quality.

The annual replacement of flocks bred for commercial egg production is high, and any method of increasing hatchability by eliminating certain individuals, producing low-hatching eggs, by methods other than actual incubation of the eggs would be of economic importance to the breeder and hatcheryman.

REVIEW OF LITERATURE

Hatchability of eggs or its component factors has been shown to be inherited. Pearl and Surface (1909) were among the first to indicate that differences in hatchability were probably inherited. Many investigators since that time have confirmed this observation.

During the past few years much interest has been shown in various measurements of egg quality, particularly interior egg quality, as evidenced by the many publications and general interest on the subject. Several workers have pointed out that if a relationship existed between interior egg quality and hatchability, the latter might be materially increased by classifying the hens for interior-egg-quality characters.

Godfrey (1936) reports the effect, on hatchability, of egg weight, quantity of total albumen per egg, and quantity of thick albumen per egg. He concludes that there is a low but significant linear correlation between hatchability and egg weight (−0.270), and also a significant curvilinear trend between hatchability and total-albumen weight per egg (−0.331), but no significant trend between hatchability and percentage of thick albumen (based on weight of total albumen) per egg (−0.205). Since both Dunn (1922) and Warren (1934) confirm Godfrey's observation on the relationship between egg weight and hatchability, it seems that the correlation between hatchability and total albumen weight per egg is another method of reporting the relationship between egg weight and hatchability. However, the percentage of thick albumen, based on the weight of the total albumen per egg, has been used by many investigators as a measure of albumen quality.

Hall and Van Wagenen (1936) report data on 265 females during a period of 4 years. Four measures of interior egg quality, namely, the score of the condition of the firm albumen, the percentage of firm albumen, the percentage of outer thin albumen, and the yolk index, were investigated. Only the score of the condition of the firm albumen showed a significant association with hatchability (-0.342 ± 0.077). This association was found both with birds that had been selected for low and high egg quality and with unselected birds. Eggs from birds that were classified as defective for the condition of the firm albumen showed an embryonic-mortality distribution distinctly different from that of the eggs from hens that were classified as having a good condition of the firm albumen. These investigators conclude that since low interior egg quality, as measured by the score of the condition of the firm albumen, is associated with low hatchability, then selection for high hatchability should tend to improve egg quality.

This last observation does not agree with the report of Godfrey. However, in these two investigations different methods of measuring interior egg quality were employed. It has been reported by Heiman and Wilhelm (1937) that the percentage of firm white (thick albumen) bears little, if any, relation to the observed grade (or score of the condition of the firm albumen) in freshly laid eggs or in eggs that have undergone the same amount of deterioration, but that the observed grade of eggs is closely related to the albumen index. If this premise were followed, hens having a low albumen index should have a low hatchability. This study was undertaken to investigate the possibility of this relationship.

MATERIALS AND METHODS

Four pens of Single-Comb White Leghorn pullets were used in this experiment. All birds were from high-producing U. S. Record of Performance hens. Housing and feeding were identical with all pens. Six consecutive weekly settings were made beginning February 28. All hens were trap-nested, the eggs marked with the hen number, pen number, and date. The hens were trapped hourly and the eggs taken directly to an egg cellar where a temperature of 60° F. or less and a relative humidity of 70 percent or more were maintained. On the evening of the production day, all hatchable eggs were removed to an egg room adjoining the incubator cellar. There the eggs were distributed to pedigree racks. In this egg room, temperature and humidity conditions were comparable with those already mentioned. All eggs were trayed 12 hours before being set and were allowed to warm to room temperature in the tray racks of the incubator cellar.

INCUBATION PROCEDURE

During the month of February 1938, two preliminary hatches were made to test the fertility of the eggs and the actual operations of the incubators. The machine used for hatching the eggs was a 1938 model, all-electric, force-draft commercial incubator, having the hatching compartment located above the setting chamber. The machine was operated between 99.5° and 100.5° F. with a wet bulb reaching between 82° and 85° at a room temperature of approximately 70°. All eggs were candled on the seventh, fourteenth, and eighteenth days of incubation. All infertile eggs and those containing dead embryos were removed, broken, and examined immediately. The time of mortality was recorded in a cell corresponding to the day that the egg was produced. In this way a clear picture of each week's performance for each hen was available at a glance. All fertile eggs removed that contained live embryos were struck from the record. On the eighteenth day all fertile eggs were placed in individual, wire, pedigree baskets and transferred to the hatcher.

TABLE 1.—*Percentage of hatch (based on number of fertile eggs set) for the six hatches*

Designation of pen	Hatch for week No.—						Average hatch
	1	2	3	4	5	6	
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
A	49.1	55.0	78.6	69.2	78.2	84.0	68.5
B	91.0	82.3	81.0	83.4	83.0	84.6	85.1
C	75.3	65.7	65.3	69.1	71.3	84.3	72.3
D	52.8	51.1	77.0	73.8	75.7	79.5	68.1
Average	66.2	63.3	75.4	70.3	76.1	81.9	72.4

TABLE 2.—*Distribution as to albumen index when the 20 extreme hens are grouped according to hatchability*

High hatchability			Low hatchability		
Hen No.	Hatchability	Albumen Index	Hen No.	Hatchability	Albumen Index
	Percent			*Percent*	
139	100	88	149	0	112
118	100	132	148	0	98
123	96	113	175	11	79
130	96	92	104	15	71
127	96	86	103	21	140
160	95	78	143	31	76
120	95	117	138	33	83
102	94	92	140	35	79
132	94	122	107	35	108
142	94	63	101	44	129

The total number of eggs, percentage of fertile eggs, percentage of hatch (based on number of fertile eggs), and time of embryonic mortality were computed for each pen or mating. The hatchability data from any hen was not used if the individual produced fewer than six fertile eggs.

In June 1938, all hens remaining in the breeding pens were classified by breaking and examining four consecutive eggs from each hen. Classification was made for the following points: (1) Egg weight in grams, a Toledo precision scale being used; (2) shell thickness, measured with a convex-anvil micrometer as described by Lund, Heiman, and Wilhelm (1938); (3) albumen height, measured at the proximal end of the line of least curvature on that part of the structural thick white having the greatest uninterrupted area, the method being that of Heiman and Carver (1936); (4) albumen index, determined by the method described by Heiman and Carver (1936) as modified by Wilhelm and Heiman (1936).

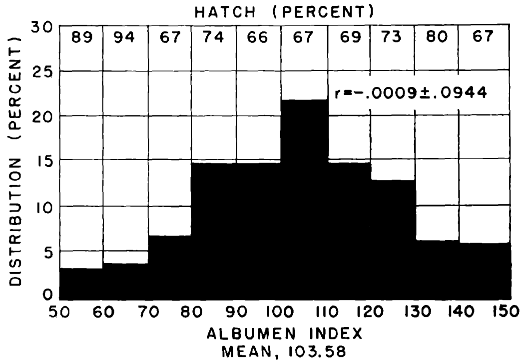

FIGURE 1.—Relationship between percentage of hatch and albumen index.

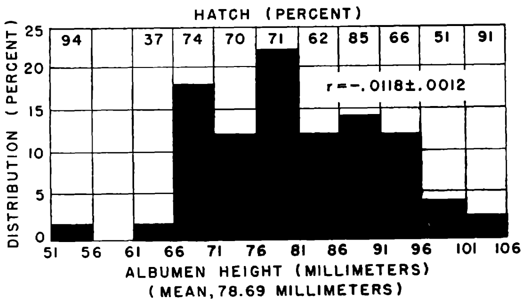

FIGURE 2.—Relationship between percentage of hatch and albumen height.

DISCUSSION OF RESULTS

Table 1 shows the hatchability (based on the number of fertile eggs set) by weeks for each pen and for the group. It will be observed that the average of all pens tended to increase from the first hatch. A comparison of the average hatchability by pens for the 6-week period shows that there was considerable variation among the pens themselves. As shown by the table, the average hatch of all fertile eggs for the experiment was 72.4 percent.

If a relationship existed between hatchability and albumen index, a grouping of the birds as to extremes of index with their accompanying hatchabilities should give an indication of that relationship. Table 2 presents an arrangement of data for 20 hens in the extreme groups both as for the mean group (100 to 109) is 67 percent for the season, whereas the average hatch for the entire group was 72.4 percent. The correlation between percentage of hatch and albumen index was found to be -0.0009 ± 0.0944. Although the correlation is negative, it is much too small to

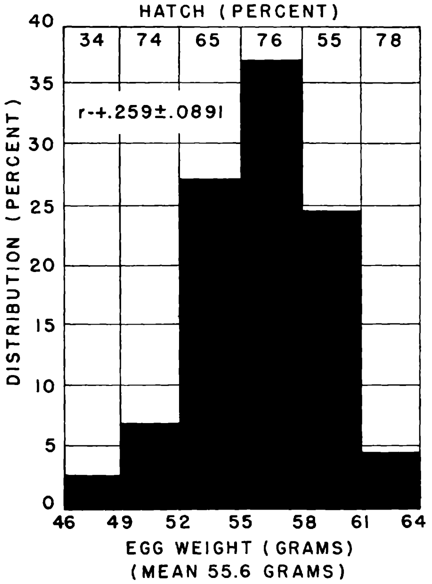

FIGURE 3.—Relationship between percentage of hatch and egg weight.

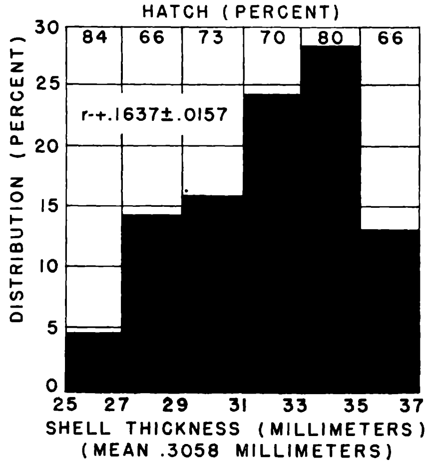

FIGURE 4.—Relationship between percentage of hatch and shell thickness.

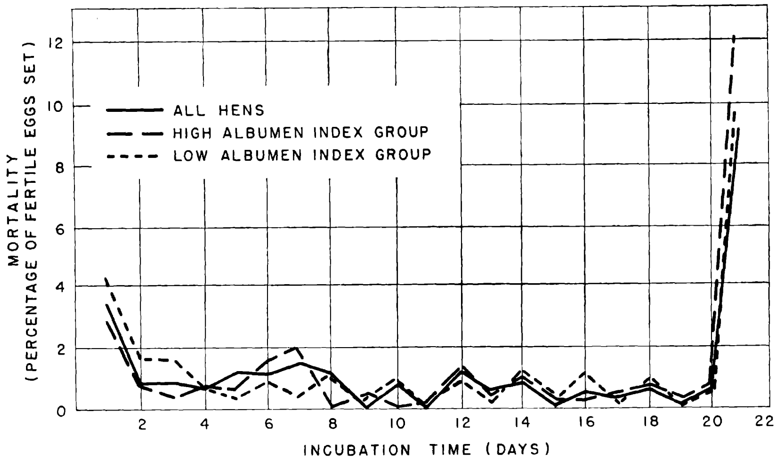

FIGURE 5.—Time of embryonic mortality

to hatchability and index. It may be noted from these data there is no consistent agreement between hatchability and albumen index.

Figure 1 shows by histogram the frequency distribution of all hens by their classified albumen index. The percentage of hatch is given by frequencies also. It will be noted that the hatch be indicative of any degree of association between the two characters considered.

The relationship between albumen height and percentage of hatch is shown by means of a frequency distribution histogram in figure 2. The mean albumen height of this group of hens was found to be 78.69. This frequency had a percentage of hatch of 71. The two extremes in albumen height had the greatest percentage of hatch, but this trend did not extend to the other frequencies. A correlation of -0.0118 ± 0.0012 was obtained between albumen height and percentage of hatch. Under the conditions of this experiment, with a range in albumen height of 51 and 105 millimeters and a range in albumen index of 50 to 150, a very close correlation ($+0.7400 \pm 0.0093$) was obtained between these two characters.

The distribution of egg weight with the hatchability by frequencies is shown in figure 3. A correlation of $+0.259 \pm 0.0891$ was obtained for these characters, with a mean weight of 55.6 grams. The correlation between egg-shell thickness and hatchability was found to be $+0.1637 \pm 0.0157$ with a mean of 0.3058 mm thickness (fig. 4.)

Figure 5 presents graphically the time of embryonic mortality for all hens in the experiment as well as for the birds segregated into high and low albumen-index groups. This figure reveals a much higher incidence of first-day mortality than has been previously reported. A small peak of mortality occurred at 7 days. A high percentage of embryos that died at the end of 21 days was found. This finding might be partially explained by the fact that other investigators have reported "pips" and "cripples" separately. An examination of the data revealed no outstanding differences as to time of mortality among the three divisions. A negative correlation of -0.0200 ± 0.0906 between egg-shell thickness and mortality on the twenty-first day was too small to be significant.

SUMMARY

All eggs produced from 61 Single-Comb White Leghorn pullets were incubated and candled on the seventh, fourteenth, and eighteenth days of incubation. All infertile eggs and those containing dead embryos were removed, broken, and examined immediately, and the time of embryonic mortality recorded for each egg. Following the hatching season, each hen was classified as to her egg weight, shell thickness, albumen height, and albumen index.

Under the conditions of this investigation the data reported indicate that two measurements of interior egg quality—albumen index and albumen height—are closely correlated, but that neither seems to be associated with hatchability. Eggs from birds having an extremely high or low albumen index hatch equally well; therefore, it appears that hatchability alone would not be a satisfactory basis for the elimination of those undesirable hens having poor egg quality. Both egg weight and shell thickness were correlated with percentage of hatch, but there was no association between shell thickness and 21-day mortality.

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INFLUENCE OF SOME PROTEIN SUPPLEMENTS ON HATCHABILITY

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INTRODUCTION

The effect of the diet fed to the laying bird on the number of chicks which can be hatched, under proper incubation conditions, from the fertile eggs incubated, has been studied in this laboratory over a 12-year period. This research program was originally designed to study the influence of various protein supplements on hatchability, but as the science of poultry nutrition advanced it became necessary to include the influence of other nutrients, particularly vitamins, in this study. It is now recognized that vitamin D and riboflavin (vitamin B_2 or G) are particularly important in hatching rations, and further, it is generally considered that the relative value of protein supplements in a hatching ration is dependent to a large degree on their content of riboflavin. However, it must still be borne in mind that the quality or biological value of the protein in these supplements, which is primarily determined by their content of amino acids and by their digestibility, may be, and probably is, also concerned. The mineral constituents of these supplements may be another factor.

A variation in hatchability due to the kind of protein supplement in the ration of the laying bird has been reported by Graham, Smith, and McFarlane (1931), Byerly, Titus, and Ellis (1933a and 1933b), Smith and Branion (1936), and the Ontario Agricultural College (1938). The relative protein efficiency, as well as the riboflavin content, of the common protein supplements has been investigated by Wilgus, Norris, and Heuser (1935). The importance of riboflavin in hatchability has been shown by Halpin, Holmes, and Hart (1933), Bethke, Record, and Kennard (1932, 1936), Heiman and Norris (1933), Davis, Norris and Heuser (1938a and 1938b), and Lepkovsky, Taylor, Jukes, and Almquist (1938). Norris, Wilgus, Ringrose, Heiman, and Heuser (1936) measured the riboflavin content of the common poultry feeds.

EXPERIMENTAL PROCEDURE AND RESULTS

In the study reported herein, 20 or 25 Barred Plymouth Rock pullets and one or two males, as nearly similar in age and breeding as possible, were used in each pen. The males were moved from pen to pen, either daily or three times each week. In case a bird died, it was replaced by one of similar breeding, but the eggs of the latter bird were not used in the hatching studied for 1 month. The birds were confined in houses, unless otherwise indicated, and were fed the experimental rations from the first of November. The individual pens were 12 feet wide and 12 feet deep, with two glass windows 3 by 3½ feet in size, and two movable celoglass screens which were removed whenever the weather was suitable, so that the birds received whatever direct sunshine was available. During a 5- to 6-month period, beginning either the first of January or February, every intact egg laid by these birds was set in the same Petersime incubator. The percentage of hatch was based on the number of fertile eggs set.

The basal diet (basal No. 1) fed to these birds in 1927 to 1932 inclusive had the following composition: Ground yellow corn, 700 pounds; wheat shorts, 500; ground oats, 300; sun-cured alfalfa meal, 150; bone meal, 37½; and iodized salt, 30 pounds. Oystershell and insoluble grit were supplied ad libitum. In addition, the birds received 1 cubic centimeter of cod-liver oil per bird per day, fed in a wet mash. This oil was not assayed and a consideration of the monthly hatches, in the light of our present knowledge, indicates that it was not a good source of vitamin D. From 1933 on, the basal diet (basal No. 2) had the following composition: Ground yellow corn, 400 pounds; yellow hominy, 100; white hominy, 200; rolled wheat, 450; wheat germ, 150; wheat bran, 50; rolled barley, 100; crushed oats, 300; oat feed, 50; ground peas, 20; soybean oil meal, 20; cod-liver meal, 10; and iodized salt, 10 pounds. One percent of cod-liver oil assaying 125 International units of vitamin D per gram was added to this basal diet from 1933 to 1935. From 1936 on, a quantity of fortified cod-liver oil sufficient to furnish 200 International units per 100 grams of mash was incorporated in the basal diet. In addition, the birds had free access to oystershell, bone meal, and insoluble grit. Alfalfa hay was also fed ad libitum except in 1937–38. In 1932–33 a third basal diet (basal No. 3), consisting of equal parts of ground yellow corn, ground wheat, ground oats, and ground barley, was fed to a few pens. In addition to the mash, each pen received a definite quantity of scratch grain, either 2½ or 3 pounds daily, depending on the number of birds in the group, on an assumed ratio of equal consumption of mash and grain. This scratch grain consisted of equal parts of cracked yellow corn and wheat.

The protein supplements studied were dried buttermilk, fish meal, meat meal, and combinations thereof, fed at various levels with the basal diets. The hatchability and egg production of the birds fed on these rations are shown in table 1. The year 1930–31 was omitted because a mild attack of laryngotracheitis occurred. Although this infection caused little or no mortality, hatchability and egg production were decidedly lowered. The year 1935–36 was devoted to a study of vitamin D requirements.

The dried buttermilk was purchased from the same company throughout the experiment, but the quality of the product obtained from 1928 to 1932 appeared to be inferior. The fish meal was obtained from the same source from 1927 to 1934, whereas that used in 1934–35 was purchased from another source. The fish meal used in 1935–36 was a mixture of two fish meals in equal proportions, the first being the same brand used prior to 1934. The meat meal was purchased from the same company from 1927 to 1935. From 1936 to 1938 it was a mixture of equal quantities of meat meal from three sources, including the original source.

Although the percentage of hatch resulting from the use of dried buttermilk as the sole animal-protein supplement in the ration was only fair in 1928 to 1932, for the 11-year period dried buttermilk was decidedly superior to either fish meal or meat meal as the protein supplement for hatching purposes. The lower hatch obtained with dried buttermilk in the earlier years may be partly accounted for by inferior processing since the product sometimes had the appearance of having been overheated, but it seems evident that an insufficient supply of vitamin D was the prime cause. In 1927–28, birds fed the basal diet supplemented with 10 percent of dried buttermilk, but exposed to one-half hour of ultra-violet irradiation daily from a mercury-vapor quartz lamp, had an egg hatchability of 74.1 percent during the same period. In 1928–29, a similar group had an egg hatchability of 76.6 percent. The superior hatchability obtained by the use of dried buttermilk in comparison with fish meal or meat meal may be partially explained on the basis of the riboflavin content of these supplements. Norris, Wilgus, Ringrose, Heiman, and Heuser (1936) gave the riboflavin content of dried skim milk as 20 units per gram, meat meal as 6, and fish meal as 10 units, but these results would not support these relative ratings. Although Heiman and Carver (1937) and Jukes and Richardson (1938) found buttermilk to be superior to skim milk in riboflavin content, we believe that there is some vitaminlike factor other than riboflavin which is intimately concerned in hatchability, as pointed out by Nestler, Byerly, Ellis, and Titus (1936) and Smith and Branion (1936), who suggested that this factor was present in liver meal and grass. Bauernfeind, Schumacher, Hodson, Norris, and Heuser (1938) also reported additional evidence of a new factor being required for growth and reproduction. We also consider that the quality of the protein itself, in these supplements, is involved, particularly since dried buttermilk has a crude-protein content of about 35 percent, whereas that of the fish meal is 60 to 70 and of meat meal 55 to 60 percent.

TABLE 1.—*Hatchability and egg production of birds fed various protein supplements*

Basal diet No.	Year	Hatchability and egg production of birds fed supplement of—								
		Dried buttermilk			Fish meal			Meat meal		
		Supplement	Hatch	Egg production per bird[1]	Supplement	Hatch	Egg production per bird[1]	Supplement	Hatch	Egg production per bird[1]
		Percent	*Percent*	*Number*	*Percent*	*Percent*	*Number*	*Percent*	*Percent*	*Number*
1	1927–28[2]	10	74.9	170.0	15	66.0	178.3	20	70.0	146.0
	1928–29	10	62.0	142.0	15	57.9	181.7	20	70.8	157.5
	1929–30	10	55.9	148.3	15	62.8	173.5	20	63.3	188.9
	1931–32	10	55.8	149.1	15	52.2	159.0	20	67.9	153.5
3	1932–33	10	74.7	177.2	5.25	38.9	155.1	7	45.6	143.1
		14	70.0	170.4	10	51.2	162.1	10	51.7	151.2
		.....	.....	.....	13	46.2	192.5	19	55.4	178.7
2	1932–33	14	74.5	184.4	5.25	45.7	182.3	7	38.3	155.4
	1933–34	14	73.3	179.2	5.25	52.1	172.4	7	41.0	142.5
	1934–35	14	70.8	171.9	14	14.3	160.4	14	14.0	170.4
	1936–37	10	76.1	169.5	12	42.7	144.1	12	46.8	165.2
	1937–38	10	77.3	161.2	.....	.....	.....	12	37.4	153.5

[1] For 11 months for 1927 to 1930 inclusive; for 10 months for the remaining years.

[2] In this year an equivalent quantity of condensed buttermilk was used.

It is evident that the value of meat meal in promoting hatchability has progressively declined throughout the period. Byerly, Titus, and Ellis (1933b) concluded that "some lots of meat meal are deficient in some substance necessary for the production of eggs capable of supporting embryonic life during the second week of incubation." Later, Titus, Byerly, Ellis, and Nestler (1936) reported that "in general, the packinghouse byproducts, besides supporting reasonably good egg production, resulted in satisfactory hatchability ranging in most cases between 70 and 80 percent." However, they found that the materials used in making meat meal were important in determining its value; ground, dried lean meat, blood meal and stick, and liquid stick were deficient for hatchability. Similar results in this laboratory were obtained in 1930–31. Using basal diet No. 1 with cod-liver oil, meat meals made from various parts of the carcass were fed at a 20-percent level. The hatch during a 5-month period was as follows when the indicated supplement was fed: Lean meat, 40.0 percent; lungs, 60.1 percent; and offal, 58.5 percent. A commercial meat meal during the same period resulted in a hatch of 62.3 percent. During the period of this study, there has been a steadily increasing demand for liver for human consumption and for the manufacture of various liver extracts. Since liver is an excellent source of riboflavin, its noninclusion in meat meal would lessen the value of the product in a hatching ration. Moreover, there has been a demand for liver meal in poultry feeding. That this is the prime factor concerned in the decreased value of meat meal is evident from the studies made from 1933 to 1936. The feeding of meat meal resulted in a 41.0-percent hatch, during the 1933–34 studies, but a combination of meat meal and liver extract (1½ grams per bird per week) gave a 62.1-percent hatch, and increasing the extract to 3 grams per week gave a 71.5-percent hatch, according to Smith and Branion (1936). Similarly, during 1934–35, feeding the same type of meat meal from the same company resulted in a hatch of 14.0 percent, whereas a combination of meat meal and liver meal resulted in a hatch of 68.2 percent. Other organs and glandular tissues are probably involved. The hatches of 46.8 and 37.4 percent obtained in 1936–37 and 1937–38, respectively, from the mixture of meat meals is additional confirmation, one meat meal being from the same company, another from a packinghouse with only a limited outlet for glandular tissues and liver, and the third from a packinghouse with no outlet.

It will be observed that there was a decline in the value of fish meal for hatching purposes. The fish meal obtained from the new source in 1934–35 was decidedly inferior. The 1936–37 results with the mixture of fish meals, half from the original source and half from a new source, suggest that there may be a decided variation in the value of various fish meals for hatchability. It is probable that the materials used and the method of processing are concerned.

Curves showing the distribution of embryonic mortality are not given in this paper, but in general with those diets which are deficient in the factors required for hatchability, there are three and possibly four peaks. These peaks, with the exception of the last one, which is generally considered to be due to incubation factors rather than nutritional (although there is some evidence that diet is also concerned since liver meal tends to reduce it), are decidedly lowered when the diet contains the required quantities of those factors furnished by milk, liver meal, or grass. Furthermore, deficient diets may produce anemia, according to Smith (1933), edema, chondrodystrophy, and teratological monsters, which are either entirely eliminated or greatly reduced by good range conditions or liver meal, as shown by Smith and Branion (1936). Byerly, Titus and Ellis (1933a) associated a high incidence of chondrodystrophy with vegetable-protein supplements. Davis, Norris, and Heuser (1938a) and Lepkovsky, Taylor, Jukes, and Almquist (1938) have reported that riboflavin-deficient diets produce "dwarf types" of embryos, many of which have a peculiar down condition, described as "clubbed down."

Table 2 shows the effect of the diet of the laying bird on the incidence of some of these abnor-

TABLE 2.—*Effect of diet on incidence of embryonic abnormalities expressed as percentage of fertile eggs incubated*

Year	Basal diet No.	Supplement		Chondrodystrophy		Edema		Monsters		Others	
		Kind	Quantity	Confined	Grass range	Confined	Grass range	Confined	Grass range	Confined	Grass range
			Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1931–32	1	Dried buttermilk	10	1.8	0.2	0.4	0.3	2.3	0.2	0.2	0.0
		Fish meal	15	2.6	.8	.5	.2	1.5	1.8	.7	.6
		Meat meal	20	0.7	1.1	.2	.8	0.9	1.0	.8	1.1
	3	Dried buttermilk	14	.6	0	.4	0	1.0	0	.1	0
		do	10	.6	0	.4	0	.6	0	.2	0
		Fish meal	5.25	.3	0	2.9	0	1.2	0	0	0
		do	10	1.0	.7	.7	.7	1.0	.7	.1	0
		do	13	1.7	1.2	1.6	0	2.1	1.8	.3	.6
		Meat meal	7	1.4	.7	2.3	.7	1.5	2.1	.5	0
		do	10	.8	0	1.3	.8	.7	1.8	.7	1.2
		do	19	.8	0	1.6	0	.8	0	.1	0
	2	Dried buttermilk	14	.1	0	.4	.5	.7	.5	0	0
		Fish meal	5.25	.4	1.1	3.5	.5	1.1	.5	0	0
		Meat meal	7	1.2	1.2	2.0	0	1.7	0	.1	0
1933–34	2	Dried buttermilk	14	.9	.9	.1	0	.4	0	.2	0
		Fish meal	5.25	.4	.4	1.9	.7	.7	.4	1.0	.4
		Meat meal	7	.1	0	4.3	.0	1.0	.5	.9	.0
1936–37	2	Dried buttermilk	10	0	....	.1	....	.3	....	....	....
		Fish meal	12	0	....	1.9	....	1.3	....	....	....
		Meat meal	12	0	....	3.1	....	1.6	....	....	....

malities in developing embryos in eggs from confined hens and from those on grass range. The diet appears to have a definite effect on the incidence of certain developmental abnormalities. The nutritive factors concerned seem to be supplied by a good grass range or by supplements such as dried buttermilk or liver meal, which are rich in riboflavin. It is probable that riboflavin is not the only factor concerned.

It appears that the rate of egg production has little or no influence on hatchability. So far as the protein supplements are concerned, the differences in egg production as promoted by these supplements are not large. Presumably, provided the laying bird receives sufficient protein and minerals, the quality of that protein as well as the other nutrients contained therein are minor factors. It is well recognized that vitamin requirements for egg production are lower than those necessary for hatchability. It should be pointed out that the term "egg production," as used herein, refers to number of eggs laid, with no reference to egg quality.

SUMMARY

In general, during an 11-year study with Barred Plymouth Rock pullets, the use of dried buttermilk as the protein supplement in rations fed to the laying birds has resulted in higher hatchability of the eggs than either fish meal or meat meal. During the last 6 years of this period, the buttermilk showed decided superiority over the other two products. From the results reported herein and other tests, it appears that riboflavin, although important, is not the only factor concerned.

The value of meat meal in promoting hatchability progressively declined during this period, owing apparently to the lessened amount of liver and other glandular tissues used in its manufacture. There also appears to have been a decline in the value of fish meal. It seems probable that there may be a decided variation in the value of different meat or fish meals for hatching rations, depending on the materials used in their manufacture and processing procedure.

A diet adequate in those factors required for high hatchability tends to reduce the incidence of embryonic abnormalities, such as chondrodystrophy, edema, and teratological monsters.

A diet capable of supporting excellent hatchability may also be adequate for good egg production.

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NUTRITIONAL FACTORS IN RELATION TO HATCHABILITY

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The purpose of this paper is to present some of the results of studies made by the research workers in poultry husbandry at the Bureau of Animal Industry's Animal Husbandry Experiment Station at Beltsville, Maryland, and by their collaborators, of the effect of diet on embryonic mortality and hatchability. Unfortunately, space is not available for a more complete presentation of this work or for a review of the large number of important researches made by others in this field.

PROTEIN

Byerly, Titus, and Ellis (1933a, 1933b) studied the effect of several protein supplements, of both animal and plant origin, on hatchability. They found no correlation between hatchability and the percentage of protein in the diet, but they observed that certain protein supplements were significantly better than others in their effect on hatchability. Their data clearly showed that the second-week embryonic mortality was greater when the protein supplements were of plant rather than animal origin. They found that a relatively large number of chondrodystrophic embryos were obtained when the former supplements were used and concluded that some of their protein supplements were deficient either in some vitamin or in the quality of the protein itself. They also found that the cause of the chondrodystrophy was eliminated by permitting the chickens to have access to range.

Titus and coworkers (1936) found that when liquid stick (the concentrated liquor from the steam rendering of fatty animal material) was used as the protein supplement, the egg production was practically as good as when a high-grade meat scrap was used but that the hatchability of the eggs was very much poorer. A mixture of blood meal and stick had an even more pronounced and deleterious effect on hatchability than did the stick alone. With both supplements there was an increase in embryonic mortality throughout the incubation period, but the increase was most pronounced during the last 11 or 12 days.

Calvery and Titus (1934) were able to demonstrate that the source of the dietary protein had no appreciable effect on the composition of the proteins of either the white or the yolk of the resulting eggs. However, the writer found[1] that if the protein content of the diet were reduced sufficiently the hatchability of the eggs was decreased, and he concluded that for good egg production and hatchability the diet should contain about 16 percent of protein of good quality.

VITAMINS

Vitamin B.—Ellis and coworkers (1933) used a diet deficient in vitamin B and vitamin G (riboflavin) and found that only about 15 percent of the resulting eggs hatched but that the hatchability was not appreciably increased by adding good sources of vitamin B (rice bran and rice polishings). Nearly all of the few chicks that hatched, when the deficient diet was fed, showed symptoms of polyneuritis soon after hatching but failed to show the symptoms when the rice by-products were added to the diet. Inasmuch as the deficient diet contained so little vitamin B that there was a very high incidence of polyneuritis among the chickens to which it was fed, it must be concluded tentatively that the essentiality of vitamin B for hatchability is doubtful or that only an exceedingly small quantity of this vitamin is required.

Vitamin D.—The writer has observed[2] that the optimum level of vitamin D intake for high egg production is about 120 International units (of the kind of vitamin D found in cod-liver oil) per 100 g of feed and that if there is enough vitamin D in the diet to support high egg production, there is enough for good hatchability. Titus and Nestler (1935) confirmed the findings of others (Branion and Smith—1932) that an excess of vitamin D from irradiated ergosterol markedly decreases hatchability and demonstrated that an excess of vitamin D from cod-liver oil has essentially the same effect.

Vitamin E.—Barnum (1935) found, as had others (Card, Mitchell, and Hamilton—1930), that a deficiency of vitamin E in the diet decreased hatchability and concluded that increased first-week embryonic mortality was an indication of vitamin E deficiency.

Unidentified factors.—The brief report of Nestler and associates (1936) suggests that good hatchability is dependent on an adequate supply of a vitamin, or vitamins, other than vitamins A, D, E, and G (riboflavin).

TABLE 1.—*Corresponding approximate percentages of phosphorus and calcium for all-mash diets and for laying mashes with which grain is to be fed*

All-mash diets		Laying mashes (with which grain is to be fed)	
Phosphorus content	Calcium content	Phosphorus content	Calcium content
Percent	*Percent*	*Percent*	*Percent*
0.6	1.9	0.8	3.7
.7	2.0	.9	3.8
.8	2.1	1.0	3.9
.9	2.3	1.1	4.1
1.0	2.4	1.2	4.2
1.1	2.5	1.3	4.3
1.2	2.7	1.4	4.4
1.3	2.8	1.5	4.6

MINERALS

Calcium and phosphorus.—Other workers (Buckner, Martin, and Peter—1925, 1929) showed that an adequate dietary supply of calcium is necessary for good hatchability, but Titus and coworkers (1937) were the first to show that too much calcium in the diet may adversely affect hatchability. These workers also found that the effect of an excess of calcium was more pronounced when the diet contained 0.9 percent of phosphorus than when it contained 1.2 percent.

Inasmuch as the laying chicken can readily adapt her physiological processes to diets containing somewhat more calcium and phosphorus than she needs, it is possible to set up standards for the calcium and phosphorus content of her diet that will be applicable under all ordinary conditions. Accordingly, the writer suggests that in all-mash diets the calcium content should be approximately as indicated in the second column of table 1, when the phosphorus content is that indicated in the first column. If, however,

[1] Unpublished results.

[2] Unpublished data.

approximately equal weights of mash and grain are to be fed, it is necessary to increase the calcium content of the mash to about the values indicated in the fourth column of the table. When an all-mash diet or a mash with which grain is to be fed supplies the appropriate percentages of calcium and phosphorus indicated, hatchability will not be affected as a result of either a deficiency or an excess of calcium. However, to prevent the chickens from consuming too much calcium, they should not be given access to either ground limestone or oystershell grit.

Manganese.—Byerly and coworkers (1935) described a nutritional disease of the chick embryo in which abnormal embryos—and chicks as well—with relatively short bones were produced in eggs laid by chickens which were fed diets that lacked some factor or factors present in wheat germ, liver, and whey. The activity, amount, or utilization of the factor or factors was augmented by permitting the birds to have access to sunshine and green range. It now is apparent from the recent work of others (Lyons and Insko—1937) that a deficiency of manganese may have been responsible, in part, for the condition which was observed.

SUNSHINE

It has been known for a long time that permitting chickens to have access to sunshine tends to improve the hatchability of their eggs, but the work of Byerly and coworkers (1937) furnishes strong evidence that sunshine supplies a factor other than vitamin D which is necessary for good hatchability.

ADAPTATION TO DIET AND THE EFFECT OF AGE OR OF STAGE OF DEVELOPMENT

Byerly, Titus, and Ellis (1933b) studied the hatchability of the eggs produced by pullets that received diets in which the protein was derived solely in one case from wheat middlings, in another from corn and corn gluten meal, and in still another from soybean meal. Some of the pullets were fed these diets from the time they were hatched and some only after they had been raised to sexual maturity on a well-balanced diet. The hatchability of the eggs from the pullets that were raised on these diets was significantly greater than that of the eggs from the pullets which were raised on the well-balanced diet. These workers concluded from this observation that, of the birds reared on the diets in which the protein was derived from these single sources, those that were less able to utilize such restricted sources of protein died before they reached maturity. In any case, the writer suggests that it is desirable to feed to breeding stock diets which are composed of essentially the same feeding stuffs as were used in the diet on which the chickens were raised.

On the other hand, the possibility must not be overlooked that the age or stage of development of chickens may affect their ability to utilize certain diets. Byerly and associates (1937) found that if pullets were fed diets in which the protein supplement was soybean meal, the hatchability of the resulting eggs progressively decreased from October to January, after which it again increased to relatively high levels. These same workers also found[3] that if the same diet were fed to yearling hens, there was no marked decrease in hatchability from October to January. Moreover, Titus and coworkers (1936) observed that pullets and yearling hens do not react in the same way to low and high levels of calcium intake. In their experiments the hens laid more eggs than the pullets on the lowest levels, but on the highest levels the pullets laid more than the hens. They found that the deleterious effect of a high level of calcium intake on hatchability was more pronounced in the eggs from hens than in the eggs from pullets.

TIME OF OCCURRENCE OF EMBRYONIC MORTALITY

Byerly, Titus, and Ellis (1933a, 1933b) and Titus and coworkers (1936, 1937) have made extensive studies of the relation between the time of the occurrence of embryonic mortality and diet. Some of their pertinent observations may be recapitulated as follows: They observed that when the protein of the diet was derived chiefly from products of plant origin, there was a marked increase in the second-week embryonic mortality. They also found that the percentage of embryonic mortality increased during the last 3 days of incubation if the calcium intake was increased to excessive levels, and that the increase was greater when the phosphorus intake was 0.9 percent of the diet than when it was 1.2 percent. These same workers also observed that the inclusion of stick or of a mixture of stick and blood meal in the diet as the chief protein supplement markedly increased the mortality throughout the entire period of incubation but that the increase was greatest after the tenth and eighth days, respectively. As was previously noted, Barnum (1935), associated increased first-week embryonic mortality with vitamin E deficiency of the diet.

From these observations and those of other workers (especially Insko and Lyons—1936 and Lyons and Insko—1937), it is evident that the mortality which occurs during the third week may be caused by several different factors and thus is attributable to cumulative effects. On the other hand, the second-week mortality and, perhaps to an even greater extent, the first-week mortality seems to be due to more definite causes.

The writer has plotted in figure 1 a composite low-embryonic-mortality curve. The data used were taken from published curves showing a low total embryonic mortality and from similar data obtained at the Animal Husbandry Experiment Station of the Bureau of Animal Industry, Beltsville, Maryland. Each plotted point represents a weighted average. This curve illustrates the approximate extent to which embryonic mortality may be reduced if all the available information on

[3] Unpublished results.

means of increasing hatchability—especially information pertaining to poultry nutrition—is utilized.

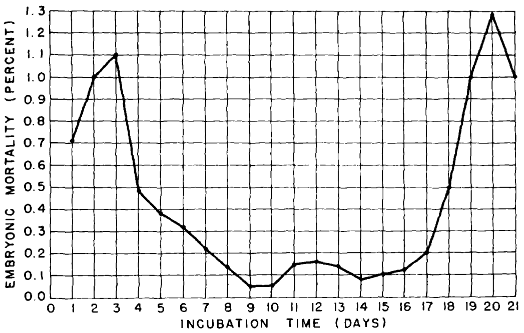

FIGURE 1.—Composite low-embryonic-mortality curve, indicating the extent to which embryonic mortality may be reduced.

SUMMARY

Studies made at the Bureau of Animal Industry's Animal Husbandry Experiment Station, Beltsville, Maryland, on the effect of diet on embryonic mortality and hatchability are reviewed, and some previously unpublished observations and conclusions are given. Hatchability appears to be influenced by the source of the protein in the diet. For good hatchability the diet should contain about 16 percent of protein of good quality. The essentiality of vitamin B for hatchability is doubtful. About 120 International units of vitamin D (of the kind in cod-liver oil) per 100 g of feed are required for the high production of hatchable eggs. Too much vitamin D from irradiated ergosterol or cod-liver oil decreases hatchability. Too much calcium in the diet decreases hatchability, but the effect is conditioned in part by the phosphorus content. Satisfactory levels of calcium and phosphorus intake are given. Sunshine supplies something besides vitamin D that is necessary for good hatchability. Adaptation to diet and the age or stage of development of chickens may affect the hatchability of their eggs. Third-week embryonic mortality is due to cumulative effects, but first- and second-week mortality appear to be due to definite causes. The approximate extent to which embryonic mortality may be reduced if all the existing information—especially that of a nutritional nature—is utilized, is indicated by an embryonic mortality curve.

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SILAGE FEEDING TO LAYING HENS

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Green feed is very important for egg production, but it is scarce and expensive during the winter in the colder countries. Therefore, many investigators have tried to replace it with feeds preserved in different ways.

Among these, silage maintains the characteristics of fresh feedstuffs better than any other, and with it the best results have been obtained in many tests, notably by Matenaers, Kuchler, Stetten, Weinmiller, Baur, and Tscherniak. Schneider, on the other hand, observed that silage is not well accepted, and Fangauf and Heensel found that results obtained are not satisfactory. This problem has not been thoroughly studied in Italy thus far; consequently, a series of tests on this subject were considered useful. These were carried on at the Provincial Poultry Yard annexed to the Zootechnical Institute and Dairy Industry Unit for Piedmont and consisted in two feeding tests on White Leghorn hens in their second laying year. The purpose of these tests was to study the effects of silage feeding in comparison with cabbage (*Brassica oleracea bullata* D. C.) and rutabaga (*Brassica napobrassica* Linn.).

THE FIRST TEST

The first test was carried on for 90 days in the winter of 1937 on three groups of 37 hens each. The hens were fed the following rations: Dry mash, 23 to 27 g per head; grains, 40 g per head; wet mash, 40 to 47 g per head; and, in addition, green feed to the control group or silage to two experimental groups.

The green feed consisted of cabbage, given whole, and chaffed rutabaga. Silage was also chaffed and mixed with the wet mash.

The silage was made up of white clover, lucerne, and mixed meadow grass preserved partly with the A.I.V. method, and partly with the cell method under experiment at the Institute. During the first test the hens ate an average of 15 g of silage per head per day. A record was made every 10 days of the hens' live weight, the number and weight of eggs laid, their organic characters (color of yolk, taste, etc.), the results of hatchings (infertile and fertile eggs, dead embryos, chicks dead in the shell, hatched chicks, etc.). Observations were also made of the palatability of the silage and of the general health of the hens.

The birds ate the green feed readily and became rather well accustomed to the silage and rutabaga.

The three groups were similar throughout in number of eggs laid and average egg weight. To test the hatchings, more than 450 eggs were incubated. The two groups fed silage had the highest percentages of fertile eggs, whereas the group fed cell-preserved silage had the highest percentage of hatched chicks. To test the *organic characters* of the eggs, one egg was taken at random every day from each group, 3 days in succession. The group fed silage produced eggs with a more yellow yolk. No difference was noticed in the taste of the eggs.

The birds in the silage-fed group had a greater increase in live weight from the beginning to the end of the test.

General-health conditions were of the best. The percentage of losses was very low in the three groups, and the cause of death, as proved by post-mortem examinations, had no relationship to the kind of feeding.

THE SECOND TEST

The second experiment was carried on for 90 days in the winter of 1938 on three groups of 21 hens.

Since the greater palatability of the tenderer silage was observed the previous year, instead of using the ordinary fodders given to cattle some rather tender lucerne was preserved separately in a small tight-wall silo, fitted with a metal cover and air-tight closing. The fodder was stored after chaffing, and mixed with molasses (1.9 percent). It had an excellent appearance when the silo was opened after 2 months. The cabbage was given whole as usual. Lucerne and rutabaga silage were chaffed rather finely.

The hens received 40 to 48 g of dry mash a day per head, 50 g of grain, and an addition of 45 g of cabbage, 17 g of rutabaga, or 40 g of silage.

Records were made of the palatability of the feeds being tested, the health of the birds, the egg production, their characteristics, and the result of hatchings, the same method being followed as in the first experiment. Monthly live weights of the hens also were obtained.

The hens gradually became accustomed to the silage, which was mixed during the first few days with some dry mash and later given separately. The rutabaga was not so well accepted.

The group fed cabbage produced the largest number of eggs, followed by the group fed rutabaga; the silage-fed group laid the smallest number. The average weight of the eggs was higher for the two groups fed silage and rutabaga; consequently, results on egg production were not consistent with those of the first experiment. The color of the yolk appeared to be of a deeper yellow in the eggs from the group fed silage than in the cabbage-fed group, this result being the same as that of the first experiment. The group fed rutabaga also gave identical results. The taste of the eggs was always normal in the three groups. Tests of hatchings, made on a total of 862 eggs, showed a higher percentage of fertile eggs and of hatched chicks for the group fed silage and rutabaga. This result confirms, for the silage, the results of the preceding year's experiment.

Live-weight variations were similar to those of the first test and they showed, in the three groups, an increase in the average weight of the hens from the beginning to the end of the experiment. The increase was highest for the silage-fed group, slightly less for the rutabaga-fed group, and lowest for the cabbage-fed group.

The general health of the hens did not suffer from the feeds received. The percentage of losses was very low, and post-mortem examination did not show any evidence of harm that could have been caused by the feeding system.

CONCLUSIONS

From the results of the two experiments, we may draw the following conclusions:

During winter it is possible to replace fresh green feeds with silage in the ration of laying hens; the hens become accustomed to these feeds quickly and eat a fairly large quantity of them (40 g). Such products, in the quantity stated, do not injure the health of the birds.

The effect of these feeds on number of eggs produced does not appear to be definite. Silage seems to have a rather beneficial influence on percentage of fertile eggs, on chicks hatched, and on the appearance of the egg yolk, deepening its color.

Silo-preserved fodders appear to have a favorable effect on the live weight of the hens. These are a means of lowering the cost of the feeding ration during the winter.

SUMMARY

Owing to the scarcity of green feeds during winter months in cold places and their high cost at the Provincial Poultry Yard annexed to the Zootechnical Institute and Dairy Industry Unit for Piedmont, it was considered advisable to try to replace, in laying hens' rations, the usual green feeds with silage preserved in different ways (A.I.V., cell silo, air-tight silo).

The tests were carried on with three groups of hens in their second laying year. They were continued for 3 months during the winter of 1937 and were repeated in 1938.

Records were made every 10 days of the hens' live weight, health conditions, egg production, weight and organic characters of the eggs (yolk color, taste, etc.), percentage of fertile eggs, eggs hatched, etc.

The results of the two quarterly periods showed the possibility of replacing, during the winter, the usual green feeds with silage in laying hens' rations. This silage, properly chaffed, is generally well accepted.

Silage is not detrimental to the general health of the birds; in fact, it seems to improve their condition, increasing the live weight.

Its action on egg production is none too clear. As for the yolk color, silage noticeably affected it, as the eggs had a yolk of a deeper yellow that is more valued.

Test on hatchings with more than 1,300 eggs showed higher percentages of fertile eggs and of chicks hatched for the group fed silage.

Although an exact calculation is not easy, the feeding of silage is definitely an economical advantage, as it lowers the cost of rations during the winter.

PRELIMINARY EXPERIMENTS ON THE NUTRITIVE VALUE OF THE CONTENTS OF THE RUMEN ON THE GROWTH OF CHICKENS

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The utilization of the contents of the rumen of slaughtered animals ought to be taken into consideration in animal nutrition in order to bring about to the Nation, a greater economy of feeding.

In these first researches there has been studied the influence of the bacterial, nutritive, and infusorial fractions of the contents of the rumen on the growth of chickens fed a balanced diet other than a possible deficiency in the quality of its proteins. The basal diet was composed of maize, fed ad libitum, partly as the ground grain and partly as a mash of maize meal; minerals (mixture of McCollum and Davis) added to the mash in the proportion of 5 percent of the weight of meal; and purified vitamins (Vogan, Vigantolo, Betabion, Cebion, each bird being fed daily: 100 International units of vitamin A, 40 of vitamin D, 50 of vitamin C, and 10 of vitamin B_1).

It was necessary to compare the influence of the infusorial fraction with those of the bacterial and nutritive ones, as in the endoplasm of the Infusoria some bacteria and alimentary particles are always present. The various fractions of the contents of the rumen were prepared with the same techniques (series of successive dilutions, centrifugations, and decantations) used in the laboratory of Usuelli by Manusardi[1] in his researches on the synthesis of vitamin B_1, produced by the micro-organism of the rumen, the only difference being that the exsiccation, instead of being performed at a low temperature, was done in bain-marie and finished in an oven at 100–105° C.

In the experiments, 16 White Leghorn cockerels of an initial weight of about one-half kilogram were used. They were divided into four groups. The first group, used as controls, was fed the previously mentioned basal diet; the second group in addition, 2 grams daily per bird of the bacterial fraction; the third group, 2 grams of the nutritive fraction; and the fourth group, 2 grams of the infusorial fraction. Every precaution was taken, by means of cement pavement, washed sand, etc., to prevent the birds from taking any other feed, worms, etc. Table 1 shows the feeding results obtained.

The experiment showed that although the weights were very uniform in the cockerels in the same group, evident differences exist among

TABLE 1.—*Feeding results obtained from the use of the different diets*

Days since the beginning of experiment	Average body weight of birds in groups fed diets indicated			
	Basal diet only	Basal diet and bacterial fraction	Basal diet and nutritive fraction	Basal diet and infusorial fraction
	Grams	*Grams*	*Grams*	*Grams*
0	482	477	484	481
10	526	520	533	550
20	575	573	576	607
30	636	618	624	656
40	669	659	660	701
50	695	705	691	760
60	704	749	714	823

the different groups. At the end of 60 days, the average weight increases, in terms of percentage of the initial average weight, were as follows: Group 1, fed basal diet, 46 percent; group 2, fed basal diet and bacterial fraction, 57 percent; and group 3, fed basal diet and nutritive fraction, 47 percent; group 4, fed basal diet and infusorial fraction, 71 percent.

The fact that the cockerels of the first group, for which the protein content of the diet was furnished by maize only, not only maintained their weight but increased it, somewhat, is not surprising when we consider that the so-called carenza maidica is a multiple lack, caused also by deficiencies of vitamins and of minerals (in our basal diet both were abundant) and that, as to the qualities of proteins, it is quite a banal error to confuse the biological value of zein with that of the proteins of maize in general.

Our experiments demonstrated that growth was not considerably influenced by the nutritive fraction of the contents of the rumen, whereas a considerably greater increase, as compared with that of the controls was evidenced from the feeding of the bacterial fraction and a much greater one from the infusorial fraction. However, as to the inefficiency of the nutritive fraction of the contents of the rumen, it must be taken into consideration that this fraction, because of the manner in which it had been prepared, did not comprise all the nutritive contents of the rumen, but only the coarser nutritive particles. On the other hand, that part, which for brevity and also a little conventionally has been called the bacterial fraction, contained, in addition to the greater part of the bacteria, the soluble substances of the contents of the rumen moreover, as the differences of weight increase between the cockerels of the first, second, and third groups, are not considerable, we must, at the present, refrain from making interpretations.

It seems, however, that no fundamental objection can be made to the results obtained with the fourth group, fed the infusorial fraction, for which the weight increase reached, within 2 months, 71 percent as compared with 46 percent for the controls. In consideration of the abundance of purified vitamins and of minerals in the basal diet, it is logical to suppose that the increase in growth was due to the quality of the proteins of the infusorial fraction. If we compare the results from the birds of this group with those fed daily the same quantity of dried matter of the nutritive and bacterial fractions, we conclude that our experiments have shown the benefit to the herbivores from the transformation of vegetable proteins of their feeds into infusorial proteins.

Gruby and Delafont were the first to point out, in 1843, the presence of an enormous quantity of Infusoria in the digestive system of different species of animals. Two papers of Fiorentini (1889 and 1890) are of fundamental importance in the study of the ciliated Infusoria which live in the rumen of the Ruminantia and in the intestine of equines. Successive publications by Bundle, Eberlein, Sharp, and others enlarge our knowledge of the taxonomy and morphology of these Protozoa. Research work on the importance of the ciliated populations in digestion in herbivores have been carried on chiefly by Mangold, Usuelli, Becker, and their schools. The reader will find references on this subject in the reviews of Mangold[2] and of Usuelli[3]. Here we shall only add that the ciliated Infusoria are present in the rumen in considerable numbers. In every liter of the contents of the rumen will generally be found 59 to 80 grams of infusoria, and about 10 to 20 percent of the entire nitrogen content belongs to the Infusoria.

In 1934 Falaschini[4] demonstrated, in the Zoo-

[1] Boll. Lab. Zool. Agr. del R. Ist. Sup. Agr. di Milano, 1931-32.

[2] Biedermanns—Zentralblatt A. N. F., Band 3, Heft 4-6. 1933.

[3] La Clinica Veterinaria. 1930.

[4] Annali del R. Istit. Sup. Agr. di Milano, vol. I, fasc. 2. 1934.

technical and Physiological Institute of Camerino, that the weight curve of sheep, during growth, in which the ciliated populations have been destroyed, is similar to that of animals with a normal infusorial fauna and which, like these, are fed hay and bran. This result is fundamental to our knowledge of the utility of the ciliated Infusoria for their hosts, but evidently it does not solve the problem completely. In fact, hay and bran represent a complete diet for ruminants. There still remains the question as to the influence of the Infusoria in case the diet is incomplete.

The problem is rather complicated; further research should be made chiefly for precise information on the biological value of the infusorial proteins, with the known methods and formula. Of greatest importance would be an analysis of the infusorial proteins especially if carried on parallel with that of the other fractions of the contents of the rumen. Such an analysis might demonstrate whether the ciliated Infusoria living in the digestive system of herbivores are capable of producing synthetically those amino acids which are indispensable for the life and growth of superior organisms. As the Protozoa of the digestive system of herbivores are rather sensible to every variation of the ordinary natural alimentary conditions of their hosts, it ought to be found out whether, in the various cases of alimentary insufficiency, especially in the more frequent ones in animal breeding, the physical-chemical conditions necessary for a flourishing development of the infusorial populations can still be found.

SUMMARY

The authors have studied the influence of the bacterial, nutritive, and infusorial fractions of the contents of the rumen, on the growth of 16 White Leghorn cockerels. These birds were fed a balanced diet except for a possible deficiency in proteins. This diet was composed of maize, minerals, and purified vitamins. The various fractions of the contents of the rumen were separated by appropriate methods and were fed, after having been dried, at the rate of 2 grams daily per bird. After a 60-day experiment, the average increases in weight, in terms of percentage of the initial weight, were as follows: For the group fed the basal diet only, 46 percent; for the group fed the basal diet and bacterial fraction, 57 percent; for the group fed the basal diet and nutritive fraction, 47 percent; and for the group fed the basal diet and infusorial fraction, 71 percent.

In consideration of the relatively large increase in weight of the last group and of the fact that the basal diet had a sufficiently high content of purified vitamins and minerals, it may be assumed that the increase in growth is due to the qualities of the proteins contained in the infusorial fraction. The results of this experiment are evidently encouraging for the utilization of the contents of the rumen in poultry feeding.

EFFECT OF FIBER AND BULK IN THE DIET OF CHICKENS ON THEIR GROWTH AND ON THE PREVENTION OF FEATHER PICKING AND CANNIBALISM

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EXPERIMENTAL

Ten-day-old White Wyandotte chickens which had received a good rearing mash from birth were used for the tests. The birds were kept indoors in compartments, the floors of which consisted of a combination of wooden slats and wire netting, each group being confined to an area of 60 square feet. An oil-burning hover heated each group. The sleeping quarters were bedded with wood wool for the first 2 weeks of the experiment, after which no bedding was used. Individual weighings were recorded, and observations were made throughout. The quantity of feed consumed per group and per individual was determined each week.

The following experiments were conducted, and the results obtained and other relevant data are outlined.

EXPERIMENT 1

This experiment was made to compare maize meal with wheat bran fed in flake form and as a meal. Three groups, 41 chickens in each, were placed on the diets given in table 1.

The final average weights after a 10 weeks' test

Table 1.—*Diet of each group in experiment 1*

Ingredient	Group 1	Group 2	Group 3
	Percent	*Percent*	*Percent*
Cod-liver oil	1	1	1
Common salt	.5	.5	.5
Limestone, ground	1	1	1
Milk powder separated	4	4	4
Meat meal	8	8	8
Pollard (middlings or wheat offals)	26	26	26
Maize meal	60	25	25
Wheat bran (flake form)	0	35	0
Wheat bran (ground into a meal)	0	0	35
Percentage of fiber	2.76	5.56	5.56

and the average feed consumption are shown in table 2.

TABLE 2.—*Average weights of birds at end of experiment 1 and average feed consumption per bird*

Group No.	Sex	Average weight per bird		Average feed consumption
		Lbs.	*Ozs.*	*Pounds*
1	Cockerels	2	12	10.75
	Pullets	2	6	
2	Cockerels	2	11	11.25
	Pullets	2	5	
3	Cockerels	2	14	10.75
	Pullets	2	9	

Feather growth proceeded at more or less the same rate in all groups, but in group 1 the individual chickens developed the habit of picking at and eating either their own feathers or those of other birds, whereas in groups 2 and 3 this habit did not appear. The insistent picking and eating of feathers leads to cannibalism, a sequel which appeared in some of the subsequent experiments.

Even though the starch equivalent of the mash fed to groups 2 and 3 was less than that of group 1, the chickens made similar growth on equal quantities of feed, indicating that the addition of bran in the quantity and the mixture used was beneficial by raising the bulk of the mixture. Bran inhibited feather picking.

EXPERIMENT 2

Experiment 2 was carried on to compare the feeding value of maize meal, wheat bran, and the fiber of wheat bran. Three groups, 43 chickens in each, were fed the mixtures as shown in table 3.

TABLE 3.—*Diet of each group in experiment 2*

Ingredient	Group 1	Group 2	Group 3
	Percent	*Percent*	*Percent*
Cod-liver oil	1	1	1
Limestone ground	1	1	1
Bone flour, sterilized	1	1	1
Common salt	1	1	1
Meat meal	10	10	10
Oats, finely ground	15	15	15
Pollard (middlings or wheat offals)	10	10	10
Barley, ground	16	7	15
Maize meal	47	21	44.5
Wheat bran	0	35	0
Bran fiber	0	0	3
Percentage of fiber	3.27	6.35	6.35

The final average weights at the end of a 10-week test and the average feed consumption are shown in table 4.

TABLE 4.—*Average weights of birds after receiving, for 10 weeks, diets used in experiment 2 and average feed consumption*

Group No.	Sex	Average weight per bird		Average feed consumption
		Lbs.	*Ozs.*	*Pounds*
1	Cockerels	1	13	10.5
	Pullets	1	8	
2	Cockerels	2	5	12.5
	Pullets	1	14	
3	Cockerels	1	14	11.0
	Pullets	1	10	

Feather picking, which resulted in cannibalism in a few cases, developed in group 1, appeared to a much less degree in group 3, and was absent from group 2.

Group 3, in whose mash wheat fiber was included, made at least as much gain as group 1; the feed consumption of both groups was approximately the same. Group 2, whose mash contained the same proportion of fiber as that of group 3, made greater gain than either group 1 or group 3, but the feed consumption was greater. It is possible also that the beneficial effect of the bran in this mixture was due to some factor in addition to bulk. Bran inhibited feather picking.

EXPERIMENT 3

Experiment 3 was made to compare the feeding value of maize meal, maize flake, and wheat bran. Three groups, 55 chickens in each, were fed the mixtures shown in table 5.

TABLE 5.—*Diet of each group in experiment 3*

Ingredient	Group 1	Group 2	Group 3
	Percent	*Percent*	*Percent*
Cod-liver oil	1	1	1
Ground limestone	1	1	1
Bone flour, sterilized	.5	.5	.5
Common salt	.5	.5	.5
Extracted soybean meal	6	6	6
Fish meal	8	8	8
Oats, finely ground	18	18	18
Pollard (middlings or wheat offals)	25	25	25
Maize meal	40	0	0
Maize (in flake form)	0	40	0
Wheat bran	0	0	40
Percentage of fiber	4.5	4.5	7.6

Table 6 shows the average final weights of the birds at the end of a 10-week test.

Feather picking developed in groups 1 and 2, causing the birds to look patchy as compared with the completely feathered chickens of group 3. The rate of feather growth was alike in all groups.

Maize flake gave a result similar to that of maize meal. An excess of fiber in the diet containing wheat bran reduces its nutritive value and checks the gains of chickens fed thereon.

TABLE 6.—*Average weights of birds after receiving, for 10 weeks, diets used in experiment 3*

Group No.	Sex	Average weight per bird	
		Lbs.	*Ozs.*
1	Cockerels	2	8
	Pullets	2	4
2	Cockerels	2	6
	Pullets	2	3
3	Cockerels	2	4
	Pullets	1	12

EXPERIMENT 4

This experiment was made to compare the feeding value of wheat bran (finely ground), oats (finely ground), and groats (dehulled oats). Three groups, 55 chickens in each, were fed mixtures made up according to the formulae shown in table 7.

TABLE 7.—*Diet of each group in experiment 4*

Ingredient	Group 1	Group 2	Group 3
	Percent	*Percent*	*Percent*
Cod-liver oil	1	1	1
Limestone, ground	1	1	1
Common salt	.5	.5	.5
Milk powder separated	4	4	4
Meat meal	8	8	8
Pollard (middlings or wheat offals)	26	26	26
Maize meal	25	25	25
Wheat bran (finely ground)	35	0	0
Oats (finely ground)	0	35	0
Groats (finely ground)	0	0	35
Percentage of fiber	5.6	5.6	3.3

The average weights recorded at the end of the 10-week test and the average feed consumption are shown in table 8.

TABLE 8.—*Average weights of birds after receiving, for 10 weeks, diets used in experiment 4 and average feed consumption*

Group No.	Sex	Average weight per bird		Average feed consumption
		Lbs.	*Ozs.*	*Pounds*
1	Cockerels	2	10	10.5
	Pullets	2	5	
2	Cockerels	2	10	10.5
	Pullets	2	5	
3	Cockerels	2	7	9.0
	Pullets	2	1	

The droppings of group 1 were much more bulky and softer than those of groups 2 and 3, which were alike in this respect. The growth of feathers in group 1 occurred sooner than in groups 2 and 3, in both of which the baby down persisted unduly long. The birds in group 1 appeared to be completely satisfied with their dietary, whereas those of the other two groups showed a curious anxiety for extraneous material. Serious feather picking developed and persisted in groups 2 and 3, but it did not occur in group 1.

As far as increase in weight is concerned, the effects of bran and oats in the dietary of chickens were the same under the conditions of this experiment. The effects on the character of the droppings, on the water consumption, and on feather growth and feather picking were dissimilar. Groats to the extent of 35 percent renders a ration unsuitable.

EXPERIMENT 5

The purpose of this experiment was to compare the feeding value of bran and oats, a mixture of oats and barley, and a mixture of oats, barley, and maize. Four groups, 60 chickens in each, were fed as shown in table 9.

TABLE 9.—*Diets of each group in experiment 5*

Ingredient	Group 1	Group 2	Group 3	Group 4
	Percent	*Percent*	*Percent*	*Percent*
Cod-liver oil	1	1	1	1
Common salt	1	1	1	1
Meat meal	13	13	13	13
Barley meal	20	20	0	0
Maize meal	40	40	40	20
Oats (finely ground)	25	5	5	5
Wheat bran	0	20	40	60
Percentage of fiber	4.3	4.3	5.3	6.9

Average weights of the birds and their feed consumption are shown in table 10.

TABLE 10.—*Average weights of birds after receiving, for 10 weeks, diets used in experiment 5 and average feed consumption*

Group No.	Sex	Average weight per bird		Average feed consumption
		Lbs.	*Ozs.*	*Pounds*
1	Cockerels	2	8	10.5
	Pullets	1	15	
2	Cockerels	2	13.5	10.5
	Pullets	2	3.5	
3	Cockerels	2	15	11.5
	Pullets	2	3.5	
4	Cockerels	2	3	12.5
	Pullets	1	15	

At the termination of the experiment the birds in group 4, which were well grown, were thinner when felt with the hand than those of the other groups. Feather growth, which was alike in groups 2, 3, and 4, was more rapid in these groups than in group 1. Feather picking developed to a very serious degree in group 1 and to a lesser extent in group 2; it became evident in group 3 on one or two occasions only; and it never appeared in group 4. Figure 1 shows the relative appearance of the birds of groups 1 and 3 at the termination of the experiment.

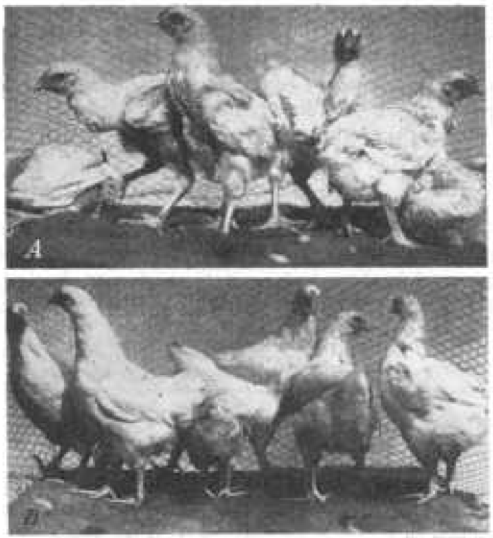

FIGURE 1.—Relative appearance of birds in group 1 (*A*) and group 3 (*B*), experiment 5.

When incorporated in the mixtures used in this experiment, wheat bran proved to be superior in its effect on weight increment, to oats and to an oats and barley mixture. As in experiment 3, the high percentage of fiber in the diet of group 4 checked the growth of the chickens notwithstanding the greater feed consumption. Wheat bran was again definitely superior to oats for feather growth and for the prevention of feather picking.

EXPERIMENT 6

Experiment 6 was made to determine the effect of introducing wheat bran into a concentrated dietary which, in the light of present knowledge, was chemically complete. The chickens were only 1 week old at the beginning of the experiment and 10 weeks old at its termination. Two groups of chickens, 20 in each, were fed the mixtures shown in table 11.

TABLE 11.—*Diets of each group in experiment 6*

Ingredient	Group 1	Group 2
	Percent	*Percent*
Cod-liver oil	1	1
Limestone, ground	.5	.5
Bone flour, sterilized	.5	.5
Common salt	1	1
Milk powder separated	5	5
Liver meal	10	10
Maize meal	62	42
Barley meal	20	15
Wheat bran	0	25
Percentage of fiber	2.1	4.0

The body weights and feed consumption of the birds are given in table 12.

TABLE 12.—*Body weights and feed consumption of birds in experiment 6*

Group No.	Average weight at end of week indicated						Feed consumed in 9 weeks
	4		6		9		
	Lbs.	*Ozs.*	*Lbs.*	*Ozs.*	*Lbs.*	*Ozs.*	*Pounds*
1	....	12.6	1	3.2	2	1.2	10.5
2	....	13.8	1	5	2	4.9	9

Serious feather picking occurred in group 1 but none in group 2. The individual and average weights of the birds in group 2 were greater than those of group 1 though not appreciably so. By increasing the bulk of the ration its nutritive value appears to have been enhanced and its effect on the behavior of the birds altered.

OTHER EXPERIMENTS

Further experiments showed that the replacement in a mixed ration of some of the maize meal by ground oat hulls so as to raise the percentage of fiber to 7.58 percent did not inhibit feather picking. They also showed that although the inclusion of 20 percent of sugar pulp partially checked this vice, a ration containing 40 percent of sugar pulp stopped it completely. Pectin was partially successful in stopping feather picking, but linseed meal and agar fed in moderate proportions proved impotent in this respect.

CONCLUSIONS

An increase in the bulk of a concentrated dietary, by the introduction of extra fiber, does not reduce, and possibly enhances, its nutritive value even though the starch equivalent is depressed.

Bulk incorporated in the form of wheat bran or beet pulp is a factor in preventing feather picking and cannibalism. Oats, with a fiber content similar to that of bran, does not inhibit this vice.

The flake and meal (ground) forms of maize have similar effects on chicken development and behavior. The same statement applies to the flake and ground forms of wheat bran.

A fiber content of 7 percent is excessive.

SUMMARY

A dietary of high calorific value is less well utilized by the chicken than one in which the concentration is reduced by the addition of a fibrous feed. When bran or oats replaces an equivalent quantity of maize in a concentrated, but theoretically complete, mixture chickens make equally

as good growth on the second dietary with a lesser calorific intake. The rendering of a feed more bulky by merely altering its physical character, as for instance the flaking of maize, has no effect in this connection, nor is the effect of the addition of such a feed as bran connected with its flaky condition.

The inclusion of fiber in excess of an optimum concentration, by limiting the daily intake of digestible material, checks the growth of the birds.

There is some evidence that the utility of fiber is related to the source from which it is supplied.

A feed mixture which, in addition to being complete, contains the proper amount of bulk and fiber, i.e., is satisfactory from the mechanical aspect, controls feather plucking. The retention, by feed, of much water in the alimentary tube and the appearance in the lower gut of bulky, semiliquid material, rather than dry, dense residues, give a feeling of satiety which inhibits the development of cannibalistic tendencies.

UTILIZATION OF CITRUS MEAL FOR POULTRY

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Since citrus meal is becoming popular for economic reasons and because of the large quantity available, it was felt that a study of its adaptability in various poultry rations would be advantageous.

Citrus meal is a byproduct of the citrus canning industry. Canning waste, amounting to two-thirds of the weight of the fresh fruit, has been used as fertilizer, but through research at the Florida Agricultural Experiment Station, a practical method of processing this waste into dry feed was found. Neal, Becker, and Arnold[1] have found the dried pulp to be a palatable and nutritious feed for dairy cattle. It has been estimated that about 10,000 tons of this dried citrus pulp were manufactured in the season of 1937–38 in Florida. Six plants at present are engaged in its production. It is expected that the supply of this feed will be steadily increased. Citrus pulp, when ground, is known as citrus meal, the product used in the feeding trials herein reported.

Almquist, of the California Agricultural Experiment Station, reported[2] in 1938 that "orange peel and pulp meal in practical chick-rearing rations" had no value and seemed to "pass through the bird like an inert substance." Sherwood, of the Texas Agricultural Experiment Station, reported[2] in 1938 preliminary studies on feeding citrus meal to poultry for egg production but found the citrus meal was not palatable and that its use resulted in low egg production. Neal, of the Florida Agricultural Experiment Station,[3] showed unsatisfactory growth and high mortality in chicks fed a high percentage of dried-grapefruit cannery refuse.

EXPERIMENTAL PROCEDURE

The experimental work was divided into four parts as follows: (1) Growth of chicks to 8 weeks of age (2) growth of pullets to 20 weeks of age (3) fattening cockerels 6 and 8 weeks of age and (4) feeding for egg production.

The citrus meal used in these experiments was processed during the season of 1936–37. The cannery refuse was minced through a feed chopper, limed slightly to remove stickiness, and then dried in a parallel-current, direct-heat rotary dryer, the small particles being sucked through the drum by a fan to the opposite end, where they were collected and ground. The temperature at the front end of the dryer was about 2,000° F., whereas the temperature at the discharge end, which regulates the drying, averaged about 220° F. The material was in the dryer about 12 minutes. The analysis, as guaranteed by the manufacturer, was as follows: Crude protein, 4.94 percent; fat, 3.02 percent; crude fiber, 11.74 percent; nitrogen-free extract, 69.13 percent.

EXPERIMENT 1—GROWTH OF CHICKS TO 8 WEEKS OF AGE

Single-Comb White Leghorn chicks of the same strain from the breeding flock at the University of Florida were used in two trials. In the first trial 250 chicks and in the second trial 125 chicks were divided equally into five groups. All chicks were wing-banded and were weighed at the beginning of the trial and at weekly intervals. Feed consumption was recorded at weekly intervals. Data were kept on the condition of the chicks, mortality, and condition of droppings. All chicks were raised in confinement batteries.

The basal diet used in these trials was as follows:

	Pounds
Yellow corn meal	40
Wheat bran	15
Wheat middlings	10
Ground oats	10

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[1] Neal, W. M., Becker, R. B., and Arnold, P. T. Dix. The feed value and nutritive properties of citrus by-products. Fla. Agr. Expt. Sta. Bull. 275; *also* Dried grapefruit refuse—a valuable feed. Fla. Agr. Expt. Sta. Press Bull. 466.

[2] Personal communication.

[3] Unpublished data (obtained in 1934).

	Pounds
Meat scrap	10
Dried skim milk	10
Alfalfa leaf meal	2
Ground oystershell	2
Salt	1

One-eighth of 1 percent of fortified cod-liver oil also was included in the basal diet.

Citrus meal replaced the yellow corn meal in the basal diet as follows: Lot 1, none; lot 2, 5 percent of the total diet; lot 3, 10 percent; lot 4, 15 percent; and lot 5, 20 percent. These diets were fed ad libitum and provided the only feed given during these trials.

TABLE 1.—*Feed consumption, weights, and mortality of Single-Comb White Leghorn chickens fed varying percentages of citrus meal to 8 weeks of age (average of two trials)*

Lot No.	Average citrus meal in diet	Average weight of chicks at beginning of trial	Average weight of birds at 8 weeks of age			Average feed consumption	Mortality
			Cockerels	Pullets	All birds		
	Percent	*Grams*	*Gms.*	*Gms.*	*Gms.*	*Grams*	*Percent*
1	0	36	630	524	585	1,695	6
2	5	38	542	477	512	1,687	9
3	10	37	440	447	446	1,493	15
4	15	38	422	372	392	1,430	44
5	20	37	341	352	345	1,392	97

Table 1 gives the weights of the birds, feed consumption, and percentage of mortality for the first 8 weeks. It may be noted that on the average the chicks in lot 1 gained 75 grams more than those in lot 2 although they ate very little more feed. The greater percentage of the mortality occurred during the second, third, and fourth weeks in the chicks of lot 5 and during the fourth and fifth weeks in those of lot 4. Chicks in lot 5 and some in lot 4 had a very unthrifty appearance, were droopy, and feed caked on the beaks prior to death. The droppings appeared more moist and darker in color as the percentage of citrus meal was increased. The lesions observed were as follows: Ascites, gelatinous fluid in the peritoneal cavity, mottled and sometimes enlarged liver, enlargement of the gall bladder, congestion of the intestines, and occasionally subcutaneous edema.[4]

Tests with pectin and naringin (glucoside)

Preliminary trials were conducted with Single-Comb White Leghorn chicks to ascertain whether or not pectin or naringin in the citrus meal was the cause of the heavy mortality experienced in the lots receiving the higher percentages of citrus meal.

Seven lots of chicks were fed as follows: Lot 1, used as control; lot 2, 1 percent of pectin; lot 3, 3 percent of pectin; lot 4, 6 percent of pectin; lot 5, 0.1 percent of naringin (glucoside); lot 6, 0.3 percent of naringin; and lot 7, 0.6 percent of naringin. Feather development in the lot fed naringin was comparable with that in the control lot, but the lots fed higher levels of pectin showed poor feather development, feed caked on the beaks, and diarrhea occurred. At the end of 4 weeks it was noted that the chicks fed the higher levels of pectin had a lower average weight than the control group. A similar condition was noted with the groups fed naringin, although these groups were heavier than the groups fed pectin. Mortality was 10 percent in the control lot, 22 percent in lot 2, none in lot 3, 33 percent in lot 4, and none in lots 5, 6, and 7, fed naringin.

[4] Post-mortem examinations were made by Dr. M. W. Emmel, veterinarian, Florida Agricultural Experiment Station.

EXPERIMENT 2—GROWTH OF PULLETS TO 20 WEEKS OF AGE

The pullets in the first four lots used in experiment 1 were reared to maturity in batteries. Table 2 shows the average weights, gains, feed consumption, and mortality of the pullets in the two trials. During the first trial four birds died, three in lot 1 and one in lot 2. In the second trial one pullet died in each of the four lots. Fowl paralysis and one case of slipped tendons caused this mortality. The incidence did not seem to be related to the feeding of citrus meal.

TABLE 2.—*Feed consumption, weights, gains, and mortality of Single-Comb White Leghorn pullets fed varying percentages of citrus meal*

Lot No.	Citrus meal in diet	Birds at beginning of trial	Average weight at—		Average gain	Average feed consumption	Mortality
			8 weeks	20 weeks			
	Percent	*Number*	*Gms.*	*Gms.*	*Grams*	*Grams*	*Number*
Trial 1							
1	0	17	494	1,281	787	5,664	3
2	5	23	484	1,209	725	5,099	1
3	10	22	452	1,196	744	5,322	0
4	15	18	373	1,123	750	5,805	0
Trial 2							
1	0	13	554	1,301	747	5,423	1
2	5	9	469	1,251	782	6,119	1
3	10	12	443	1,144	701	5,549	1
4	15	9	372	986	614	6,382	1

EXPERIMENT 3—FATTENING COCKERELS

Two lots of Single-Comb White Leghorn cockerels, 60 and 75 to the lot, brooded in batteries, were divided equally into five groups at 6 and 8 weeks of age and fed 0, 5, 10, 15, and 20 percent of citrus meal for periods of 5 and 4 weeks, respectively.

Table 3 shows the average weights, gains, and feed consumption of the cockerels during the fattening period. No mortality occurred during either of these feeding periods.

TABLE 3.—*Feed consumption, weights, gains, and mortality of Single-Comb White Leghorn cockerels during fattening period on diets containing varying percentages of citrus meal*

Lot No.	Citrus meal in diet	Birds at beginning of trial	Average weight at— 6 weeks	Average weight at— 11 weeks	Average gain	Average feed consumption	Mortality
	Percent	*Number*	*Gms.*	*Gms.*	*Grams*	*Grams*	*Number*
Trial 1							
1	0	12	420	1,053	633	2,539	0
2	5	12	422	1,031	609	2,598	0
3	10	12	427	1,000	573	2,662	0
4	15	12	427	962	535	2,613	0
5	20	12	427	819	392	2,341	0
Trial 2							
1	0	15	566	1,055	489	2,025	0
2	5	15	585	1,080	495	2,123	0
3	10	15	591	1,048	457	2,193	0
4	15	15	595	1,051	456	2,315	0
5	20	15	592	924	332	2,132	0

EXPERIMENT 4—FEEDING FOR EGG PRODUCTION

Ninety-six Single-Comb White Leghorn pullets (lots 1, 2, 3, 4), reared to maturity in the previous trials (experiment 2) were placed in individual laying cages, the same number in each cage. They were fed all-mash rations containing 0, 5, 10, and 15 percent citrus meal, the citrus meal replacing yellow corn meal in the following basal diet:

	Pounds
Yellow corn meal	42.5
Wheat bran	15
Wheat middlings	10
Alfalfa leaf meal	5
Meat scrap	6
Dried skim milk	5
Ground oats	10
Ground limestone	4
Salt	0.5
Cod-liver oil	2

These pullets started in production late in July 1937 with an average, in the first 28-day period, of 2.0 to 4.0 eggs per pullet. A molt commencing during the second period and lasting for the next four periods reduced production and feed consumption. The average egg production per pullet for twelve 28-day periods was as follows: Lot 1, 110 eggs; lot 2, 98 eggs; lot 3, 99 eggs; lot 4, 100 eggs. Considering the low level of egg production and small variation, the results have little significance, even though the lot receiving no citrus meal produced the greatest number of eggs.

Feed consumption per bird varied from 67 pounds to 74 pounds, the group on the highest level of citrus meal consuming the most feed. The control birds (lot 1) were the heaviest of the four lots at the end of the laying period.

A high mortality was experienced with the birds in laying cages, it being 58.3 percent in lot 1, 50 percent in lot 2, 37.5 percent in lot 3, and 41.7 percent in lot 4. Fowl paralysis, leukemia, or chronic hemocytoblastosis was responsible for all losses.

Experimental work is now under way with four lots of pullets (50 in each lot) on range, use being made of various levels of citrus meal to ascertain further the value of citrus meal for egg production.

DISCUSSION

Citrus meal replacing yellow corn meal in the chick diet, in proportions of 0 to 20 percent, resulted in a decrease in rate of growth during the first 8 weeks. The chicks on the 5-percent level had a rate of growth nearly equal to that of the control lot. However, with the higher citrus-meal levels the rates of growth decreased rather markedly. This decrease appeared to be most pronounced during the first 4 weeks. Feed consumption during the first 8 weeks decreased sharply as greater percentages of citrus meal were fed. Mortality was exceedingly high in the groups receiving the 15- and 20-percent levels of citrus meal. In the first trial, with the group receiving 20 percent of citrus meal the chick mortality was 94 percent during the first 8 weeks, in the second trial, 100 percent.

Pectin or naringin added at various levels to the chick diet resulted in a decrease in growth, but no excessive mortality similar to that in the group fed 20 percent of citrus meal occurred. Further experimental studies are needed to ascertain the cause of the heavy mortality when 15 and 20 percent of citrus meal were fed to chicks. There is a possibility that a combination of pectin and naringin would result in conditions similar to those obtained from feeding the higher levels of citrus meal.

Pullets from 8 to 20 weeks of age appeared to be able to utilize citrus meal more efficiently than chicks up to 8 weeks of age. In trial 1 the gain was greatest in the group receiving no citrus meal and lowest in the group receiving 5 percent, but in trial 2 the gain was greatest in the group receiving 5 percent of citrus meal and lowest in the group receiving 15 percent. Feed consumption varied considerably in the two trials but was greatest in the group receiving 20 percent of citrus meal. Mortality during this period did not appear to be related to the percentage of citrus meal in the diet.

Cockerels fed citrus meal beginning at 6 weeks of age appeared able to utilize it more efficiently than did chicks up to 8 weeks of age. However, the gain during a 5-week feeding period decreased as the percentage of citrus meal in the ration increased. In another trial, in which cockerels 8 weeks of age were used, the rate of gain during a 4-week period was rather uniform with the exception of the group receiving 20 percent of citrus meal. No mortality occurred in either of the two age groups of cockerels. No detectable difference was noted in the quality of the cooked meat of the cockerels fed the various levels of citrus meal.

In the experiment in feeding pullets for egg production, in which 0 to 15 percent of citrus meal was included in an all-mash ration, excessive mortality occurred but did not appear to have any relationship to the percentage of citrus meal in the ration. Egg production in all groups was low, owing to the prolonged molt during the winter and the high mortality, yet there appeared to be little difference in the average number of eggs per bird. Birds fed 15 percent of citrus meal consumed the greatest quantity of feed, indicating that the ration was palatable.

A representative number of eggs from each of the four groups were examined. There did not appear to be any significant difference in the quality of the eggs, as determined from color of yolk and percentage of thick and thin albumen. Likewise, there was no detectable difference in either the raw or cooked eggs from the different lots.

Examination of feed-consumption, growth, and egg-production records showed an apparent lesser value for citrus meal than for yellow corn meal, as on a comparable rate of feed intake there was less growth and production and on a comparable production greater feed intakes were required.

SUMMARY

Feeding trials were made with growing chicks, fattening cockerels, growing pullets, and laying birds, which were fed 0 to 20 percent of citrus meal (ground dried cannery refuse) as a substitute for yellow corn meal in the diet. These trials were conducted to study the effect of the citrus meal on growth, feed consumption, mortality, quality of eggs and meat, and egg production. All trials were conducted in batteries, and a total of 625 Single-Comb White Leghorns were fed all-mash diets.

Chicks fed citrus meal showed decreased growth rate, compared with the controls, during the first 8 weeks, particularly during the first 4 weeks, the decrease being greater at the higher levels. Twenty percent of citrus meal in the chick diet resulted in the death of almost all the birds. Pectin and naringin, at the levels found in the citrus meal, gave decreased growth rates.

Two lots of cockerels 6 and 8 weeks of age were fattened for 5 and 4 weeks, respectively. Growth curves of birds receiving 5 and 10 percent of citrus meal were comparable with those of the control group, although more feed was required per unit of gain when citrus meal was fed. No mortality resulted and no detectable difference was noted in the quality of the meat.

Pullets from 8 to 20 weeks of age appeared to be able to utilize citrus meal, as the rate of gain compared favorably with that of the control group. There was no relationship between percentage of citrus meal and pullet mortality.

Laying birds, when fed as much as 15 percent of citrus meal, showed no significant difference in numbers of eggs produced, mortality, or quality of eggs. However, production was unsatisfactory in all groups.

IMPORTANCE OF FISHERY BYPRODUCTS IN POULTRY NUTRITION

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Few persons realize the importance of fishery byproducts in poultry nutrition, nor do they have any knowledge of the extent to which these byproducts are used in poultry and livestock feeds. Furthermore, fishery byproducts possess certain nutritional properties which make them particularly desirable and essential as ingredients of mixed feeds and poultry rations. It is interesting to study the development and gradual economic rise of these fishery byproducts and their relation to the modern poultry industry of today. For instance, about 10 years ago, fish meal as a feedstuff was little known to the American farmer and little used by him. Most of the fish meal made in the United States at that time was either used in this country as an ingredient of fertilizers or was shipped to foreign countries, where the farmer had a greater appreciation of the value of fish meal as an animal-protein concentrate. Likewise, about 10 years ago, very little was known regarding the value of various fish oils and fish-liver oils, produced in the United States, as potential sources of vitamins A and D for both human and animal nutrition. At that time, cod-liver oil was practically the sole source of these vitamins, not only in human nutrition and for medicinal use, but also in poultry feeding. Other fish oils and fish-liver oils produced in this country in commercial quantities were not marketed as a source of vitamins but were sold for industrial purposes, such as the manufacture of soap, paints, varnishes and linoleum, tempering of steel, and leather sizing, in which other saponifiable oils and fats were utilized.

Because the United States produced less than 10 percent of its domestic consumption of cod-liver oil and, therefore, was dependent on foreign sources of supply for 90 percent of the cod-liver oil used, technologists of the United States Bureau of Fisheries undertook a study of the availability of domestic fish oils and fish-liver oils as sources of supply of these necessary vitamins. Since it is well known that the poultry industry is dependent on cod-liver oil and other fish oils as sources of vitamin D, and since, contrary to popular notion, baby chicks rather than human babies consume most of the vitamin-bearing fish oils in this country, it was believed that any beneficial results from these investigations would be as valuable to the poultry industry as to the producers of these domestic fish oils. The results are given in the scientific literature of the last 10 years. As a practical outcome of these pioneering investigations, such fish oils and fish-liver oils as pilchard (sardine), salmon, tuna, herring, shark (dogfish), halibut, burbot, swordfish, cod, and menhaden, are available not only to the drug industry for human nutrition but also to the poultry industry at prices which give the domestic fish-oil producer a better market than he obtained for industrial uses and, at the same time, a cheaper price and a wider selection to the feed manufacturer and the poultry farmer of this country. Not only that, but since some of these oils contain as much as 100 times the vitamin D potency of the average cod-liver oil, the recent introduction of fortified oils has made it possible for the poultry feeder to use smaller percentages of the oil in his feeds in order to provide the same protection against vitamin D deficiencies.

Because of experiments conducted by technologists of the Bureau of Fisheries and by other investigators, showing the excellent properties of fish meal as an ingredient of livestock rations, accompanied by improvements in the quality of fish meal made in this country, there has been a great increase in the use of fish meal in animal feeding in the United States during the last 10 years. This increase has been so great that in spite of the fact that in the meantime the domestic production of fish meal has greatly expanded, today the United States consumes more fish meal than it produces and is forced to import the remainder. True, some domestic fish meal is exported, but the imports of fish meal exceed the exports. The following fish meals and shellfish meals produced in this country are available to the poultry industry: Menhaden; ground fish or "whitefish," such as cod and haddock; herring; mackerel; pilchard (sardine); salmon; tuna; shrimp, crab; and whale. These fish meals vary somewhat in composition according to the type of raw material and method of manufacture used.

From the standpoint of the composition of the raw material from which fish meals are made, these meals may be divided into two principal classes, the oily and nonoily meals. By far the most of the meal is in the former class. Oily fish are those which store their oils throughout the entire body and have relatively small livers in proportion to the total body weight of the fish. Examples of this type of fish are salmon, pilchard (sardine), tuna, mackerel, menhaden, and the various types or species of herring. Nonoily fish store their oils principally in the liver and other vital organs, and the body of the fish contains relatively small percentages of oil. These fish possess livers much larger than those of oily fish, in proportion to the total body weight. Examples of nonoily fish are cod, haddock, pollock, hake, and cusk. Because of this great variation in oil content of the raw materials, the resultant fish meal from these different classes of fish vary considerably in oil content. Since the oil is present largely at the expense of the protein, so-called nonoily fish meals are somewhat higher in percentages of protein and much lower in oil. This oil, originally, has both vitamin and energy values, but because of the high heat to which it is subjected in the process of manufacturing fish meal and because of its gradual deterioration or oxidation in the meal in storage after manufacture, it sometimes is an undesirable factor from the standpoint of the value of the product as a feedstuff. In some methods of drying fish meal, the oil is not damaged so greatly during the process of manufacture. Technological investigations are now being conducted for the purpose of improving conditions of processing and storage to prevent or retard the oxidation or rancidity of the oil in fish meal.

Fish meal is valuable principally as a protein concentrate, although it is also a good source of minerals, both in quantity and variety. Animal husbandrymen in some of the State agricultural experiment stations also have found that certain types of fish meals, properly processed, are good sources of vitamins A, D, and G. In most feeding tests conducted at Federal and State experiment stations and by private investigators, fish meals have been found to be, in general, superior to other animal and vegetable protein concentrates. Fish meal is certainly an excellent ingredient of the poultry ration, and the demand for it by the feed manufacturer is increasing.

There are produced in commercial quantities in this country certain shellfish meals, such as shrimp and crab meals, which also have been shown to be excellent ingredients of poultry feeds. Although the protein content of these shellfish meals is usually lower than that of fish meals, the quality of the protein is excellent. Shellfish meals are higher in mineral content than fish meals.

Although the quality of fish meal produced in the United States is improving rapidly, there is much yet to be known regarding its manufacture, handling, shipment, and storage. Methods of drying have considerable influence on the subsequent composition, food value, and keeping qualities of fish meals. Various types of dryers, such as flame, direct and indirect hot air, steam, and vacuum types, are in commercial use in the United States for the manufacture of fish meal. There is a need for better standards for fish meal and more uniform methods of analysis to enable the Federal and State feed-control chemists to regulate the sale and use of fish meal to the ultimate benefit of both producer and consumer. It cannot be emphasized too strongly that fish meal, like other organic materials, is a perishable commodity, and, if not properly manufactured, often causes great losses and disastrous fires. The experience of technologists shows that, in order to produce a fish meal which will be a stable commodity under ordinary conditions of handling and storage, the finished product must be held to an oil and moisture content of 6 percent each. Excessive percentages of moisture and oil, either or both, in fish meal have been the cause of rapid decomposition and deterioration in nutritive value, of overheating (sometimes resulting in disastrous fires), and the cause of some friction and misunderstanding in the industry. Furthermore, excessive percentages of moisture tend to defraud the consumer because, in such cases, the feed manufacturer and the farmer are paying fish-meal prices for water. Since the oil in most commercial fish meals, by the time the meal reaches the consumer, also has little nutritive value, the same is true of excessive percentages of oil.

Other fishery byproducts which are extensively used in poultry feeding are oyster- and clam-shell products and kelp meal. Everyone is familiar with the time-honored use of crushed oyster- and clam-shell meals as a source of calcium in the poultry ration. However, not many persons are acquainted with kelp meal. This product is of more recent origin in this country and in the last few years has gradually increased in usage in the poultry industry. Most of the kelp or seaweed meal available on the market in the United States is manufactured from the giant brown kelp of the Pacific coast. The kelp is harvested from beds along the Pacific coast by an especially adapted type of mowing machine. This wet kelp is then dried and ground into a meal, which, in appearance, resembles alfalfa meal. Kelp meal is considered to be about equal to alfalfa meal in vitamin A content, but its principal value is as a mineral supplement.

SUMMARY

This paper contains a general discussion of the development and technical and economic importance of fishery byproducts as ingredients of poultry feeds. It deals with the manufacture and uses of various fish oils and fish-liver oils as sources of vitamin D essential to poultry nutrition, the different types of fish and shellfish meals as protein concentrates and mineral supplements in the poultry ration, and oyster- and clam-shell products and kelp meal as valuable mineral supplements in poultry feeds. The effects of methods of manufacture on composition, food value, and stability also are reported, and a need is expressed for better standards and more uniform methods of testing for quality. Historical data on the development of domestic fish meal and fish oil industries and of their rise, respectively, from the fertilizer and soap industries to the valuable foodstuffs of today, are also given.

SECTION 3. PATHOLOGY AND DISEASE CONTROL

THE POULTRY-DISEASE SITUATION

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Poultry husbandry plays an important role in the economic affairs of our time. The poultry industry of the United States is valued at approximately one billion dollars. Diseases of poultry cost this country about 100,000,000 dollars annually. In 1937, C. M. Ferguson of the Ohio State University made an extensive survey of adult mortality among laying flocks in 10 States. Mortality cost these States 32,000,000 hens and 43,500,000 dollars a year, the average mortality being 18.8 percent. In the 12 to 15 years previous to 1937, mortality had increased 70 percent in these 10 States and 127 percent in Ohio. The fact that the poultry industry, in spite of such handicaps, is still considered profitable is highly remarkable and decidedly in its favor. One can hardly conceive of other branches of the animal industry surviving under like circumstances.

Ferguson states that there is evidence that this mortality is still mounting. Can it be, then, that the situation is hopeless? That it is not so can be seen from results of disease-control measures practiced on individual farms as well as over larger areas. The application of the results of research in the bacteriological, immunological, parasitological, pathological, nutritional, and, more recently, the genetic aspects of poultry diseases offers much hope for the future. In spite of the fact that most institutions have given only casual attention to research in poultry pathology, many notable contributions applicable to disease control have been made, for example:

The discovery of the cause and mode of the spread of pullorum disease, and later, the perfection of serologic diagnostic tests now widely used in the control and eradication of this disease.

The perfection of the tuberculin test and its application to the control of avian tuberculosis.

The discovery that pox in birds is a virus disease and the development of protective vaccines.

A similar discovery in the case of laryngotracheitis.

The discovery of the cause of blackhead and of the control of this disease by proper management of yards.

Additional knowledge of the life cycles of intestinal parasites through which more or less effective sanitary control measures may be devised. Also the discovery of the vermifugal effect of nicotine carbon tetrachloride and tetrachlorethylene and the vermicidal effect of colloidal iodine.

The discovery of several new species of coccidia and the working out of their life cycles, the knowledge of which is essential to sanitary control measures.

The discovery that botulism, (limber-neck) in birds is caused by *Clostridium luciliae* or *Clostridium botulinum* type C and that an effective antitoxin may be prepared against this disease.

That deficiency of vitamins will cause various types of disturbances, for instance, a deficiency of vitamin A causes nutritional roup in chickens, pasty eyes in ducklings, and a somewhat similar disease in turkeys; of vitamin B, polyneuritis; of vitamin D, rickets; of vitamin E, lowered fertility; of vitamin F, lowered fertility and retarded growth; of vitamin D, chick paralysis; and of vitamin K, hemorrhage; a deficiency of the gizzard erosion factor causes erosions and hemorrhages in the gizzard.

Further knowledge of the role of calcium and phosphorus in the metabolism of poultry as well as the discovery that a deficiency of manganese is at least partly responsible for a malady known as perosis or slipped tendon.

Much knowledge concerning fowl leucosis.

The discovery that birds are susceptible to tularemia and encephalomeylitis, diseases which affect man.

The discovery that *Salmonella aertrycke*, which is a fairly common cause of food poisoning in man, occurs frequently in turkeys, pigeons, canaries, and chickens.

We note certain trends in the increase and decrease in the prevalence of poultry diseases. Leucosis has a tendency to decrease in prevalence in flocks that have been afflicted for several years, whereas in newly infected flocks it increases more or less rapidly. Fowl plague will disappear from flocks completely of its own accord in certain areas. Fowl cholera and fowl typhoid have become almost extinct in Michigan. Blackhead, on the other hand, is increasing conspicuously in chickens in our State. Pullorum disease will spread readily if given a chance.

Theoretically one might offer explanations for these trends, but actually we do not always know why some diseases increase in prevalence and others decrease. Thus, much remains to be done in an effort to solve the many problems connected with poultry mortality. Special attention should be paid to the host, its mechanism of resistance, and the factors that govern it. Is it not true that we are spending more time and effort in the study of microbes than the animals they afflict? Should we not make a concerted effort to determine the composition of feedstuffs and their effect on health? Most feed formulas show how much corn, bran, alfalfa, etc., they contain. It seems equally, if not more, important to know the quality of each one of these ingredients. This leads us back to the soil and its composition. To carry out research along these lines requires an elaborate organization. A marked step in advance has been taken in the establishment of the Poultry Disease Regional Laboratory at East Lansing, Michigan. Here the bacteriologist, chemist, geneticist, pathologist, and poultry husbandman will work together, and if proper balance can be maintained in the efforts of these workers, much should be accomplished. Not only may the poultry industry gain by such research, but Pasteur having conceived the idea of using attenuated bacteria for protective immunization from his work with chickens, it may not be too much to assume that knowledge, valuable to medicine in general, may come from such a comprehensive research program as that put into operation by the United States Department of Agriculture and the 25 cooperating States centering their activities in the laboratory in East Lansing.

In the field of poultry-disease research therapeutics should not be forgotten. Although sanitation, selective breeding, and nutrition are the ideal means by which to prevent disease, it may safely be assumed that, as long as man is imperfect, his practices will be imperfect, and diseases will, therefore, find their way into his flocks. Why should we not make an effort to find remedies for poultry diseases? After acting as adviser to poultrymen in matters of disease control for 18 years, I am tired of having to say: there is no remedy. One of the chief curses of the poultry industry is the medically ignorant but commercially clever and unscrupulous nostrum vender. Scientific research, education, and proper legislation are necessary to combat this evil.

Finally, success in controlling and eradicating poultry diseases requires close cooperation on the part of all groups concerned—research men, teachers, control agencies, merchandisers, and not the least, the poultryman himself. An attitude of honesty, frankness, and confidence must be maintained at all times to prevent misunderstanding and mistrust, through which any sensible disease-control program may be wrecked.

ERFAHRUNGEN IM GEFLÜGELGESUNDHEITSDIENST

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Es kann hier nicht meine Aufgabe sein, über die Erfolge des Geflügelgesundheitsdienstes zu berichten, wie er, meinen Anregungen (Beller, 1933) entsprechend, im Jahre 1936 von Grzimek in Deutschland eingeführt worden ist. Über seine Organisation und seine Erfolge wird Weissgerber vor diesem Kongress berichten, dem die zentrale Leitung und damit die Verwertung des in epidemiolgischer und züchtungsbiologischer Beziehung ausserordentlich aufschlussreichen statistischen Materials zur Aufgabe gemacht ist. Ich spreche vielmehr als Leiter eines der 22, über das ganze Reichsgebiet verteilten Untersuchungsinstitute von den Erfahrungen, die man da im täglichen Verkehr mit den Züchtern, vor allem mit den im Geflügelgesundheitsdienst zusammengeschlossenen Herdbuch- und Vermehrungszuchten zu machen Gelegenheit hat.

Im Vordergrund steht noch immer die Bekämpfung der Kückenruhr und zwar weniger wegen der Ausfälle in den genannten, hygienisch ausnahmslos auf hoher Stufe stehenden Betrieben, als vielmehr mit Rücksicht auf die z.T. sehr erheblichen Aufzuchtverluste in den bäuerlichen Geflügelhaltungen. Man darf dabei allerdings die ursächliche Verknüpfung nicht auf das *Bact. pullorum* beschränken, sondern muss neben den Umweltsverhältnissen auch die konstitutionelle Anlage berücksichtigen. Als auslösende Faktoren kommen neben *Bact. pullorum* häufig *Bact. coli commune*, *Bact. pycyaneum* und, wie Schäfer (1939) nachgewiesen hat, auch *Bact. pseudotuberculosis rodentium* zur Beobachtung, sodass man in aetiologischer Beziehung manchmal ein sehr buntes und nicht immer einheitliches Bild erhält. In Wirklichkeit umfasst also die Kückenruhr viel mehr und vor allem vielseitigere Krankheitszustände, als man gemeinhin mit Bezug auf einen spezifischen Erreger, das *Bact. pullorum*, darunter versteht.

Vom streng wissenschaftlichen Standpunkt aus ist es also eigentlich nicht berechtigt, die Möglichkeit zur Stellung von Regressansprüchen auf den Nachweis des *Bact. pullorum* oder spezifischer Antikörper bei den Legehennen zu beschränken, denn die Kückensterblichkeit kann in einem serologisch gänzlich negativen Bestand hoch, in einem stark verseuchten Bestand aber gering sein. Dies hängt von dem Zusammenwirken der äusseren und inneren Krankheitsbedingungen ab, von denen vorstehend die Rede war. Trotz dieser Erkenntnis (Beller und Zunker, 1936) halten wir an der Blutuntersuchung fest. Sie bildet einen in ihrer moralischen Wirkung nicht zu verkennenden Sicherheitsfaktor für eine Herdbuchzucht und hält den Züchter an, der Auslese unter den Legehennen die nötige Beachtung zu schenken, damit die Zahl der ruhrempfänglichen Kücken möglichst niedrig gehalten wird. Auf diese Weise ist dann gleichzeitig dem Käufer und Züchter gedient, dessen Sanierungswille die hauptsächlichste Triebfeder bei der Durchführung des Geflügelgesundheitsdienstes bilden muss.

Der Streit um die Methode der Blutuntersuchung, vor allem darüber, ob die Langsam- oder Schnellagglutination zu verwenden ist, erscheint uns müssig. Die Entscheidung darüber möge man jedem einzelnen Institut überlassen, denn sie ist mehr eine organisatorische als eine wissenschaftliche Frage. Grundsatz allerdings muss sein, dass die Ausführung der Reaktion in einer Hand bleibt. Ist es also nicht möglich, jeden einzelnen Geflügelbestand selbst aufzusuchen, so muss man sich die Blutproben in das Institut schicken lassen, um sie dort zu verarbeiten. Ausschlaggebend ist nicht die Methode sondern der Erfolg, und der hängt ebensosehr von der gewissenhaften Durchführung der hygienischen Massnahmen, beginnend mit der Ausmerzung der reagierenden Legehennen, wie von der Blutuntersuchung ab. Voraussetzung dafür ist ein Vertrauensverhältnis zwischen Züchter und Institut, dessen Fachtierarzt mit den besonderen Verhältnissen jedes einzelnen Betriebes vertraut sein muss und deshalb keinen allzu grossen Wirkungskreis haben darf. Die Anwendung der Schnellmethode bietet, wenn er die Blutentnahme nicht selbst vornehmen kann, unter diesen Umständen den Vorteil, dass der Fachtierarzt jedes Tier eines Bestandes zu sehen bekommt und bei dieser Gelegenheit den Gesamtbestand auf Mängel der verschiedensten Art untersuchen kann.

Bei den Augenveränderungen, die man auf diese Weise zu sehen bekommt, erhebt sich die, auch schon von te Hennepe und Fritzsche (1937) aufgeworfene Frage, inwieweit man eine Verfärbung des Iris mit der Hühnerlähmung in Zusammenhang bringen darf. Wir vertreten den Standpunkt, dass das Abweichen der Iris von der roten Farbe zum mindesten eine vorübergehende oder dauernde Konstitutionsschwächung bedeutet und berufen uns dabei auf die Untersuchungen Freerksens (1938) am menschlichen Auge, auf Grund deren dem in der Iris sichtbar zutage tretenden Mesenchym eine gewisse konstitutionsdiagnostische Bedeutung zukommt. Wenn also vielleicht auch nicht lähmekrank, so erscheinen uns Legehühner mit derartigen Veränderungen doch nicht gesund genug, um ihre Verwendung zur Zucht ratsam erscheinen zu lassen. In dieser Ansicht wurden wir bestärkt durch den Nachweis von histologischen Veränderungen an den Nerv. optici, über die in anderem Zusammenhang berichtet wird.

Eine andere, viel verbreitete Krankheit, die man bei derartigen Besichtigungen feststellen kann, ist der Hühnerschnupfen, den wir unbekümmert um seine verwickelten aetiologischen Zusammenhänge in der Hauptsache als ein hygienisches Problem betrachten. Regenreiche Länder mit grosser, dem Sättigungsgrad nahen Luftfeuchtigkeit bieten den Vögeln keine optimalen Entwicklungsmöglichkeiten. Kommen dazu noch niedrige Temperaturen oder starke Luftbewegungen, so ist der Wärmeverlust so beträchtlich, dass eine katarrhalische Entzündung der oberen Luftwege einschliesslich der Trachea die unausbleibliche Folge ist, zumal wenn die Hühner noch anderen schwächenden Einflüssen unterliegen. Ich denke dabei in erster Linie an den in unseren Breitegraden ausserordentlich häufigen Parasitenbefall, von dem anschliessend noch die Rede sein wird. Für seinen Erwerb ist in erster Linie der Auslauf, für den des Schnupfens dagegen der Stall, seine Lage und Beschaffenheit verantwortlich zu machen. Nicht jeder Platz eignet sich ohne weiteres für ein freistehendes Hühnerhaus. Auf Einzelheiten einzugehen, ist hier im Rahmen eines kurzen Referates nicht möglich.

Dagegen möchte ich, ihrer nicht minder grossen Bedeutung wegen, noch kurz auf die parasitären Erkrankungen zurückkommen. Sie sind den Untersuchungen von Franken (1938) zufolge, wenigstens in unserem Untersuchungsbezirk, trotz ihrer grossen Verbreitung auf die nachstehend genannten, wenigen Parasitenarten beschränkt, deren prozentuale Feststellung sich auf die Häufigkeit ihres Vorkommens im Verlauf eines Jahres bezieht.

		Prozent
Nematoden	*Ascaris galli*	32,3
	Heteratis gallinae	51,1
	Capillaria retusa u. *longicollis*	20,5
Cestoden	*Davainea proglottina* *Raillietina cesticillus* *Raillietina echinobothrida* *Choanotaenia infundibulum* *Amoebotaenia sphenoides*	33,1

Hierzu ist zu bemerken, dass sich die Bandwurmerkrankungen fast ausschliesslich auf *Davainea proglottina* und auf *Raillietina cesticillus* beziehen, die eine hämorrhagische Darmentzündung verursachen. Darauf ist es zurückzuführen, dass Cestodenbefall fast doppelt so häufig tödlich endigt als Nematodenbefall, der in Farmbetrieben wegen des direkten Entwicklungskreises vorherrscht, während in den bäuerlichen Geflügelhaltungen der Cestodenbefall wohl deshalb häufiger ist, weil diese Betriebe bessere Lebensmöglichkeiten für die Zwischenwirte der Hühnercestoden bieten.

Wenn man nun den Parasitenbefall in Beziehung zu dem Alter der Hühner, sowie zur Temperatur und Niederschlagsmenge in den einzelnen Monaten des Jahres setzt, so ergeben sich interessante Zusammenhänge. So findet man, dass der Spulwurmbefall am häufigsten zu beobachten ist bei 9–12 Monate alten Junghühnern, die in Farmbetrieben auf offenbar verseuchten Weiden gehalten werden. Am meisten gefährdet sind die Junghennen, die, nachdem sie den Winter im Stall zugebracht haben, im Frühjahr mit den bereits erwachsenen Legehennen den Auslauf teilen müssen. Einem steilen, auf diese Weise erklärten Anstieg der Verteilungskurve für den Spulwurmbefall im April folgt ein langsamer Abfall bis zum Herbst, während die Verbreitung der verwandten Heterakiden dem Jahresverlauf der Temperaturkurve folgt und damit eine Abhängigkeit von klimatischen Einflüssen erkennen lässt. Sie treten ebenfalls deutlich in die Erscheinung bei dem Haarwurmbefall, dessen jährliche Schwankungen der Niederschlagsmenge parallel gehen. Temperatur und Feuchtigkeit fördern mit den dazugehörigen Zwischenwirten auch den Cestodenbefall, der im Herbst, also gerade umgekehrt wie der Spulwurmbefall, seinen Gipfel erreicht.

Auf diese Weise wird die Standortsbedingtheit der Geflügelzucht vermehrt ins Licht gestellt und die Gefahr beleuchtet, die zu enge Ausläufe unter ungünstigen klimatischen und Bodenverhältnissen zwangsläufig heraufbeschwören. Praktisch besteht sie bei jedem grösseren Betrieb von vorneherein, oder die Hühnermüdigkeit des Bodens stellt sich im Laufe einiger Jahre ein. Ihr vorzubeugen, verlangt eine genaue Kenntnis der exogenen Schädlichkeiten, deren Berücksichtigung neben den eingangs genannten endogenen Faktoren eine regelmässige Kontrolle aller Todesfälle zur Voraussetzung hat, wie sie der Geflügelgesundheitsdienst für die Herdbuch- und Vermehrungszuchten vorsieht. Laboratoriumsuntersuchung und Bestandsberatung arbeiten so zusammen, um mit der Feststellung der Krankheiten und ihrer Ursachen die Wege zu ihrer Bekämpfung zu ebnen.

ZUSAMMENFASSUNG

Der Geflügelgesundheitsdienst erfordert eine individuelle Behandlung jedes einzelnen Betriebes, die ebenso den inneren Zuchtwert als auch die äusseren Verhältnisse zu berücksichtigen hat. Dazu gehören die allgemeinen und die besonderen klimatischen Bedingungen, die Bodenbeschaffenheit, die Grösse des Auslaufs und seine Bearbeitung, sowie der Stall. Da die Umweltsverhältnisse mit ihren einzelnen Faktoren grosse schiedenheiten aufweisen, der Organismus aber auf diese Einflüsse zweifellos auf das Feinste reagiert, erscheint es von vorneherein aussichtslos, Geflügelzucht nach einheitlichen und gleichgesetzlichen Richtlinien zu betreiben. Es gibt natürliche Leistungsgrenzen, die einem Betrieb in gesundheitlicher Beziehung gesetzt sind. Sie im Einzelfall zu ermitteln und nach Möglichkeit zu erweitern, ist die Aufgabe des Geflügelgesundheitsdienstes.

Die restlose Erfassung aller Todesfälle und ihre sachverständige Beurteilung bildet somit für einen Zuchtbetrieb ein wichtiges Mittel nicht nur für die möglichste Einschränkung derartiger Ausfälle sondern zugleich auch für die richtige Abschätzung der Endaussichten, die derartige Bemühungen im Einzelfall versprechen. Der Kampf gegen widrige Umweltseinflüsse bestimmt ebenso wie die Erbanlage von vorneherein das Maaß der Leistungen einer Zucht.

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SUMMARY

The poultry health service requires individual treatment of each enterprise, where the breeding value of the stock as well as surrounding conditions have to be taken into consideration. This includes general and particular climatic conditions, the nature of the soil, the size of the range and its care, and finally the poultry house. As these surrounding conditions with their individual factors are widely different, and because the organism undoubtedly is highly sensitive to these influences, any attempt to lay down uniform lines for the breeding and keeping of poultry would be futile. There are natural limits for each establishment with regard to health and sanitary conditions. It is the task of the poultry health service to find these limits for each enterprise and to extend the same as far as possible.

Therefore, the investigation and competent diagnosis of all causes of death are of great importance to a breeding station, not only for the reduction of losses but also for arriving at correct conclusions as to the ultimate results which may be expected of such measures in the individual case. The combating of adverse surrounding conditions is just as important for the production of a flock as heredity.

IMPORTANCE OF NONSPECIFIC PATHOLOGICAL CONDITIONS IN CAUSING MORTALITY AND CULLS IN LAYING FLOCKS[1]

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The purpose of this paper is to report on the relative frequency of the occurrence in adult chickens of various types of pathological conditions unrelated to infection, parasitism, or diseases of an otherwise specific nature and to focus attention on the significance of these nonspecific diseases as causes of adult-poultry mortality.

SOURCES OF DATA

The material presented was obtained by the systematic autopsy of (1) all chickens more than 6 months old that died or were removed as culls from the flock (hereafter referred to as the P. H. flock) of the Division of Poultry Husbandry, University of California, during the 4-year period April 1933 to April 1937; and (2) all chickens that died on seven specialized poultry farms (the flocks hereafter being referred to as farm flocks) during the 19-month period November 1, 1934, to May 31, 1936. A more detailed account of the data concerning the P. H. flock has been recently given by Lubbehusen[2] and Beach[3]. The farm flock data, however, much of which was collected by W. H. Busic[4] have not previously been published. All flocks consisted almost entirely of White Leghorns.

THE P. H. FLOCK

Description of the chickens.—The chickens utilized for these studies were hatched each April during 1933 to 1936, inclusive, from both production and experimental types of mating. At the age of 5½ months, the pullets were individually classified as grade A, B, or C, leg-banded, and distributed to the various pens of the laying houses, without regard to grade. Approximately 85 percent showed the high qualities required for the grade A or B classification. This, together with the fact that the number leg-banded comprised approximately 90 percent of the total pullets hatched, is indicative of the adequacy of brooding conditions and freedom from disease which obtained during the rearing period.

The specific-disease conditions present in the flock were lymphomatosis and intestinal coccidiosis. There was a high incidence of the former in both the dead birds and the culls. The coccidial infection, however, never became widespread and was so effectively controlled by sanitation that it was a negligible disease factor. The flock was, and continues to be, otherwise free from all diseases related to infection or parasitism, a conditions which makes it possible to evaluate more accurately the importance of pathological conditions of nonspecific origin.

The dietary regime was the same for all chickens until the end of the first laying year, when those not retained for breeders were either removed for autopsy or used in nutrition experiments. The diets fed in the nutrition experiments, although necessarily of varying composition, usually contained adequate quantities of all known nutritive requirements. The data concerning any group on a deficient diet are not included in this report.

Culling periods.—During July of each year, all pullets then 16 months old and in their eleventh month of production and whose production for the preceding 2 months had been irregular or lacking were removed for autopsy to determine whether there was a pathological reason for this condition.

At the age of 19 months, the conclusion of the first laying year, all chickens not retained for breeders or for nutrition experiments were killed for autopsy. Many of these had excellent production records, were in perfect health and normal at autopsy, and cannot be correctly classed as culls. Breeders with poor production records were culled in January of their second laying year, at which time they were 22 months old. At 27 months, all chickens which had been retained for nutrition trials were removed and autopsied. Many of these, like the 19-month-old birds, were good producers and would not have been removed from a privately owned flock. These periodic cullings account for the large number of normal chickens (table 2) found among culls more than 18 months old.

No chickens were removed as culls at other than the designated periods, unless their physical condition was such that their return to health and production was unlikely.

Autopsy procedure.—The dead birds were brought to the laboratory so promptly that decomposition was rarely encountered. The culls were subjected to both ante- and postmortem examination. For a considerable period, the inoculation of blood-agar slants with heart blood, liver, and spleen was a routine procedure. The media so consistently remained sterile, however, that this practice was discontinued except for occasional cases with lesions of a nature suggestive of bacterial infection.

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[1] Acknowledgment is made of laboratory and clerical assistance provided by the Works Progress Administration.

[2] Assistant veterinarian in the Experiment Station, University of California; resigned December 31, 1937.

[3] LUBBEHUSEN, R. E., and BEACH, J. R. Adult poultry mortality of non-infectious origin. Jour. Amer. Vet. Med. Assoc. (In press.)

[4] Associate in veterinary science, University of California; resigned June 30, 1936.

Classification of lesions.—The nonspecific disease conditions were classified according to the anatomical system to which the organs affected belonged, i.e., the alimentary, included with which are the liver and spleen; the urinary; respiratory; circulatory; and reproductive. Lesions of other organs or systems were assigned to a miscellaneous group. However, since more than 80 percent of all lesions were of the alimentary, urinary, or reproductive system, in the data presented the lesions of all organs not a part of these three systems were placed in the miscellaneous group.

Generally, the diagnoses were made on the basis of the gross pathology, but all lymphomatous and other neoplastic conditions were identified by histopathological examinations. The pathological conditions of a nature and magnitude believed capable of having caused death or, in the case of the culls, of ultimately causing death if the chicken had remained in the flock, were classed as primary lesions. Lesions of a more minor nature and seemingly of little present or potential menace to health were classed as secondary and are not included in the tabulated data. When lesions of sufficient import to be classed as primary were present in the organs of two or more anatomical systems of the same individual, all were counted. Consequently, the number of primary lesions exceeds the number of chickens which were autopsied.

The autopsy data are further segregated to show the relative frequence of occurrence of nonspecific pathological conditions of the same general type in chickens of different ages. Thus the chickens are grouped in age periods of 7–12 months, 13–18 months, 19–24 months, and 24–36 months.

Incidence of nonspecific disease.—Tables 1, 2, and 3 show that nonspecific disease was responsible for 62.5 percent of the total mortality; that the nonspecific type of primary lesions was present in 59.8 percent of the culls which had primary lesions, and, therefore, that the combined actual and potential mortality due to nonspecific disease amounts to 61.3 percent of the total actual and potential mortality of 22.7 percent of the birds in the flock. The nonspecific-disease conditions were of secondary importance at 7–12 months of age, when the incidence of lymphomatosis was high, but in all older groups, 70 percent or more of the primary-disease conditions were of nonspecific origin.

Alimentary-system involvement.—Nonspecific disease of some organ of the alimentary system accounted for approximately one-fourth of the primary lesions in the dead birds and one-third of those in the culls (tables 1 and 2). The incidence in the dead chickens was slightly greater in the group 7–12 months of age than in older groups and, in the cull chickens, was highest in the group 19–24 months old. The major lesion in more than half of the dead birds was degeneration of the liver which, in many cases, had resulted in the rupture of that organ and intra-abdominal hemorrhage. Other pathological changes of particular importance were enteritis and proventriculitis, each of which occurred in approximately one-fifth of those with alimentary-system involvement. In the culls, enteritis was predominant, degeneration of the liver and proventriculitis being encountered less frequently. The general health of many of the culls with enteritis did not appear to be seriously impaired at the time of autopsy, and recovery might have taken place if these chickens had been allowed to live. The extent of the damage to the intestinal mucosa, however, made it seem more likely that their health soon would have declined and that they either would have been culled because of poor physical condition or would have succumbed.

Urinary-system involvement.—This condition

TABLE 1.—*Age incidence and distribution of nonspecific pathological lesions in chickens that died in P. H. flock*

Age (months)	Birds in flock	Total dead birds		Birds dead of nonspecific disease[1]: Total	Proportion of— Total dead	Proportion of— Birds in flock	Primary lesions[2]	Distribution of primary lesions: Alimentary system		Urinary system		Reproductive system		Miscellaneous	
	Number	*Number*	*Percent*	*Number*	*Percent*	*Percent*	*Number*	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]
7–12	4,278	295	6.9	94	31.8	2.1	233	81	34.7	34	14.5	62	26.6	56	24.0
13–18	2,700	523	19.3	375	71.7	13.8	535	121	22.6	105	19.6	241	45.0	68	12.7
19–24	1,826	210	11.5	147	70.0	8.0	234	51	21.7	75	32.0	77	32.9	31	13.2
More than 24	758	136	17.9	112	82.3	14.7	159	37	23.2	27	16.9	64	40.2	31	19.4
Total or average of all ages	9,562	1,164	12.1	728	62.5	7.6	1,161	290	24.9	241	20.7	444	38.2	186	16.0

1 Nearly all the other deaths were caused by lymphomatosis.

2 Pathological conditions believed capable of having caused death. When two or more such conditions were present in one chicken, all were classed as primary and counted. Lesions of secondary significance are not included in this tabulation.

3 Percentage of total primary lesions.

consisted in derangements of the kidneys, characterized in most cases by swelling and paleness of the organs, urate stasis, and consequent distention of the tubules. It constituted approximately one-fifth of the nonspecific primary lesions in the dead birds and one-sixth of those in the culls. In the dead, its incidence was greatest The involvement of this system was relatively low in both the dead chickens and the culls 7–12 months of age. It was of somewhat greater but of less than average frequency of occurrence in the dead birds 19–24 months of age. However, in the corresponding group of culls and in both the dead and culls of other age groups, the repro-

TABLE 2.—*Age incidence and distribution of nonspecific pathological lesions in the culls from P. H. flocks*

Age (months)	Birds in flock	Culls: Total	Culls: With primary lesions	Culls with lesions[1] of nonspecific disease[2]: Total	Proportion of— Total culls with primary lesions	Proportion of— Birds in flock	Primary lesions[1]	Alimentary system		Urinary system		Reproductive system		Miscellaneous	
	Number	*Number*	*Number*	*Number*	*Percent*	*Percent*	*Number*	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]	*Number*	*Percent*[3]
7-12	4,278	391	369	96	26.0	2.0	145	49	33.7	18	12.4	17	11.0	61	42.0
13-18	2,700	351	279	187	67.0	6.5	213	65	30.5	12	5.6	104	48.8	32	15.0
19-24	1,826	718	260	228	87.6	12.4	237	89	37.5	16	6.7	111	46.8	21	8.8
24-36	758	377	101	93	92.0	12.2	100	27	27.0	5	5.0	54	54.0	14	14.0
Total or average	9,562	1,837	1,009	604	59.8	6.3	695	230	33.0	51	7.3	286	41.1	128	18.4

[1] Account is taken only of lesions of such nature and location that they had affected the health of the chicken or that probably would have caused death if the chicken had not been removed from the flock. Lesions of such a minor nature that they were not considered as likely ever to affect the health of the chicken were disregarded.

[2] Nearly all the other culls with primary lesions were affected with lymphomatosis.

[3] Percentage of total primary lesions.

TABLE 3.—*Age incidence and distribution of nonspecific pathological lesions in the dead birds and culls*

Age (months)	Birds in flock	Total dead birds and culls with primary lesions[1]		Dead birds and culls with nonspecific primary lesions: Total	Proportion of Total dead birds and culls with primary lesions	Proportion of Birds in flock	Primary lesions	Alimentary system		Urinary system		Reproductive system		Miscellaneous	
	Number	*Number*	*Percent*	*Number*	*Percent*	*Percent*	*Number*	*Number*	*Percent*[2]	*Number*	*Percent*[2]	*Number*	*Percent*[2]	*Number*	*Percent*[2]
7-12	4,278	664	15.5	190	28.6	4.4	378	130	34.3	52	13.7	79	20.8	117	30.9
13-18	2,700	802	29.5	562	70.0	20.5	748	186	24.8	117	15.6	345	46.1	100	13.3
19-24	1,826	470	25.7	375	79.7	20.5	471	140	29.7	91	19.3	188	39.9	52	11.0
24-36	758	237	31.2	205	86.4	27.0	259	64	24.7	32	12.3	118	45.5	45	17.3
Total or average	9,562	2,173	22.7	1,332	61.2	13.8	1,856	520	28.0	292	15.7	730	39.2	314	16.9

[1] Refers only to pathological conditions which were believed to have caused or, in the case of culls, to be capable of causing death.

[2] Percentage of number of primary lesions.

in the group 19–24 months of age; in the culls, the distribution was fairly uniform at all ages except 7–12 months. Some of the affected chickens died after a brief illness and were still in a good state of nutrition. Others lived until they had become markedly emaciated.

Reproductive-system involvement. — Approximately 40 percent of all nonspecific primary lesions were found in the reproductive system. ductive system was the seat of 40 to 54 percent of the nonspecific-disease conditions.

The condition known as ruptured yolk with resultant peritonitis was the most frequent finding in the dead birds and a common, although not predominant, finding in the culls. Culture media inoculated from a number of these cases usually remained sterile, but several yielded a pure growth of *Escherichia coli*. The significance, if any, of the presence of this organism is not known. Other common findings were occlusion of the oviduct (usually with caseated masses of egg material), salpingitis, and varying quantities of entire or crushed shell or "soft shell" eggs in the abdominal cavity, the result, apparently, of reverse peristalsis of the oviduct. The last was a particularly common finding in the cull chickens more than 12 months of age.

Miscellaneous lesions.—No single type of the nonspecific pathological conditions of this group was seen frequently enough to be, in itself, of particular significance. The most numerous were injuries inflicted by other chickens, peritonitis of unknown origin but which may have resulted from ruptured yolk some time previously, and neoplasms not classed as lymphomatous.

THE FARM FLOCKS

Description.—Six of the seven flocks were operated primarily for commercial egg production and one was a trapnested breeding flock. The equipment and management of the flocks were slightly better than average. The farms were scattered over a roughly circular area, approximately 25 miles in diameter. The chickens on all farms were confined to houses, with small dirt yards, with smaller concrete-surfaced yards, or with no yards at all.

Procedure.—The dead chickens were picked up by the caretakers and immediately placed in a refrigerator, from which they were collected two or three times each week and taken for autopsy to an especially equipped building on one or the other of two farms. By this method of handling, decomposition before autopsy was almost entirely avoided. The facilities for autopsy provided for microscopic examination but not for further bacteriological studies. This deficiency was overcome by taking, from time to time, representative specimens to a nearby laboratory for culturing. In no instance was any infectious disease identified by the laboratory examinations which had not been detected by the autopsies on the farms.

Included with the dead is a considerable number of chickens which were culled and killed because they were not in a salable condition. However, a much larger number of chickens which were culled because of poor physical condition had some salvage value and were marketed. Many of the latter were chickens in the beginning stage of neurolymphomatosis and still in good flesh. Consequently, data on the farm flocks do not provide so complete a picture of the disease situation as that obtained for the P. H. flock.

The method of classification and tabulation of the disease conditions in the farm flocks is the same as for the P. H. flock, except that the age grouping of the former was 5 months to 1 year, 1 to 2 years, and more than 2 years, instead of in periods of 6 months.

Specific diseases present.—Specific-disease conditions accounted for the death of 46.5 percent of the total of 4,770 chickens which were autopsied (table 4). Diseases most frequently encountered were lymphomatosis, intestinal coccidiosis, and coryza. Of lower incidence were infectious laryngotracheitis, fowl pox, and ascariasis.

As with the P. H. flock, the incidence of specific disease was highest in the lowest age group and was increasingly lower as the age of the chickens increased.

Incidence and distribution of nonspecific disease.—Both the percentage (53.4 percent of the total) of chickens dead from nonspecific disease and the type and distribution of primary lesions are strikingly similar to those of the P. H. flock, as can be seen by comparing tables 1 and 4. It is, therefore, unnecessary to give a detailed discussion of these factors for the farm flocks. More than 80 percent of all primary lesions were located in the alimentary, urinary, or reproductive systems. The incidence of alimentary-system involvement, enteritis in particular, was considerably higher during the ages of 5 months to 1 year than in birds of these ages in the P. H. flock. This may have been related to the higher incidence of intestinal coccidiosis in the farm flocks, evi-

TABLE 4.—*Age incidence and distribution of nonspecific pathological lesions found at autopsy in 4,770 chickens in seven farm flocks*

Age (months)	Total dead birds	Birds dead from specific disease		Birds dead from nonspecific disease										
				Total dead	Proportion of total dead	Primary lesions[1]	Distribution of primary lesions							
							Alimentary system		Urinary system		Reproductive system		Miscellaneous	
	Number	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Number*	*Percent*[2]	*Number*	*Percent*[2]	*Number*	*Percent*[2]	*Number*	*Percent*[2]
5–12	1,443	796	55.1	647	44.8	941	452	48.0	141	14.9	179	19.1	169	17.9
13–24	2,359	1,151	48.7	1,208	51.2	1,767	506	28.6	371	21.0	594	33.6	296	16.7
More than 24	968	274	28.3	694	71.6	870	211	24.2	174	20.0	346	39.8	139	15.9
Total or average	4,770	2,221	46.5	2,549	53.4	3,578	1,169	32.6	686	19.2	1,119	31.2	604	16.9

[1] Pathological conditions believed capable of having caused death. When two or more such conditions were present in one chicken, all were counted.

[2] Percentage of primary lesions.

dence of enteritis having remained after parasite had disappeared. In other respects, the type of lesions found and their distribution were, as already stated, very similar to those previously described for the P. H. flock.

DISCUSSION

These data, obtained by the careful and systematic autopsy of approximately 7,000 chickens of laying age, more than two-thirds of which came from commercial poultry flocks, reveal that more than half of the deaths resulted from pathological conditions apparently unrelated to infection, parasitism, or other specific-disease condition. Specific diseases, particularly lymphomatosis, intestinal coccidiosis, and coryza, were predominant during the first laying year but thereafter such diseases assumed a place of relatively minor importance.

The autopsy of apparently healthy chickens culled from the P. H. flock because of unsatisfactory egg-production records revealed that approximately one-third of them had pathological changes involving the reproductive organs, from which recovery was improbable and which were responsible for the chickens becoming poor producers. This finding is illustrative of the part which nonspecific-disease conditions may play in affecting egg production as well as the health of the chickens.

Because of the high incidence of nonspecific-disease conditions, it seems obvious that the mortality rate among adult chickens will not be reduced to a satisfactory level solely by the further development and application of methods for the control of infections and parasites. The poultry raiser would still suffer from excessive losses in his flock from degenerative changes and functional disturbances in the organs due to disease conditions of obscure origin. The solution of this disease problem will require that pathologists depart from the time-honored custom of concentrating their efforts on infectious and parasitic disease and thoroughly investigate the influence which factors such as genetics, nutrition, management, and environment may have in causing the various types of pathological changes and disturbances of function of the organs. In other words, it will be necessary to make use of branches of biological science other than bacteriology and pathology to elucidate means for the reduction of losses from nonspecific disease. A research program of this nature is already in effect cooperatively by the Divisions of Veterinary Science and Poultry Husbandry of the University of California. A result which appears to have been obtained thus far is a sharp reduction in losses from a certain type of disorder of the digestive system by the elimination of certain families of breeders[5]. This minor success makes us hopeful of the future effectiveness of this method of approach to the adult-poultry problem.

[5] Taylor, L. W., and I. M. Lerner. Breeding for egg production. Calif. Agr. Expt. Sta. Bull. 626, p. 43. 1938.

SUMMARY

The material for this report was obtained by the systematic autopsy of (1) all chickens more than 6 months old that died or that were removed as culls from the flock (termed the "P. H. flock") of the Division of Poultry Husbandry, University of California, during a period of 4 years; and (2) all chickens of laying age that died on seven specialized poultry farms (the flocks being termed "farm flocks") during 19 consecutive months.

In the P. H. flock the deaths amounted to 1,164; the culls, 1,837. The latter included chickens in poor physical condition, those discarded because of unsatisfactory egg production, and all surplus hens not needed for breeders or for nutrition experiments. Many of these surplus hens had good production records, were in perfect health and normal at autopsy, and would not have been removed from a privately owned flock. They were, nevertheless, killed for autopsy so that the pathological record of the flock would be complete.

The number of farm-flock chickens autopsied was 4,770. These included all the dead and a considerable number of culls which were not in salable condition. However, a large number of chickens culled because of poor physical condition had some salvage value and were marketed. Consequently, the data on the farm flocks do not provide so complete a picture of the disease situation as that obtained for the P. H. flock.

Lymphomatosis and intestinal coccidiosis were the only specific-disease conditions present in the P. H. flock. The incidence of the former was high in both the dead birds and the culls. The coccidial infection, however, was so effectively controlled by sanitation that it was a negligible disease factor.

The specific diseases encountered in the farm flocks were lymphomatosis, infectious coryza, and intestinal coccidiosis.

The lesions not related to any of the specific diseases mentioned were classified according to the anatomical system of the body in which they occurred. However, more than 80 percent of the nonspecific lesions occurred in the alimentary system (including the liver and spleen), the urinary system, or the reproductive system, and, therefore, in the data presented, all lesions of organs not a part of these three systems were placed in a miscellaneous group. Consideration was given, in tabulating the data, only to pathological conditions of a nature and magnitude believed capable of having caused death, or, in the case of the culls, of ultimately causing death if the chicken had remained in the flock.

Such nonspecific-disease conditions were responsible for 62.5 percent and 53.4 percent, respectively, of the mortality in the P. H. flock and in the farm flocks and were present in 59.8 percent of the culls from the P. H. flock.

The incidence of the types of pathological conditions found varied according to the age of the chickens, and the variations were similar in both the P. H. flock and the farm flocks. The alimentary system was the predominant location of lesions in chickens 6 to 12 months old; the reproductive system in chickens from 12 months old or more. Involvement of the urinary system ranked third in frequency in all age groups. The major lesion of the alimentary system was degeneration of the liver which, in many cases, had resulted in rupture of that organ and intra-abdominal hemorrhage. Other pathological changes of importance were enteritis and proventriculitis. In the reproductive system, the condition known as ruptured yolk with resultant peritonitis was seen more frequently than other conditions. Other common findings were occlusion of the oviduct with caseated masses of egg material, salpingitis, and varying quantities of entire or crushed shell or soft-shell eggs in the abdominal cavity, the result apparently of reverse peristalsis of the oviduct. The last was particularly common in cull chickens more than 12 months of age. The urinary-system involvement consisted of derangements of the kidneys, characterized in most cases by swelling and paleness of the tissue, and urate stasis with consequent distention of the tubules.

Another point of interest is that approximately one-third of the chickens which were culled from the P. H. flock because of unsatisfactory egg production had pathological conditions from which recovery was improbable and which were responsible for the chickens becoming poor producers. This fact illustrates that nonspecific disease may affect egg production as well as the health of the chickens.

The elucidation of the causes and means of avoiding mortality from nonspecific disease will require that investigators of poultry disease employ branches of biological science other than bacteriology and pathology. A research program of this nature is already in effect at the University of California. The minor success obtained makes us hopeful of the future effectiveness of this method of approach to the adult poultry-mortality problem.

COMBATING POULTRY DISEASES IN THE NETHERLANDS

By Dr. B. J. C. te Hennepe, *The State Serum Institute at Rotterdam, Rotterdam, Netherlands*

Within a relatively small area in the Netherlands 30,000,000 poultry are kept. Even with this concentration the health and production of the flocks are maintained at a high level. This is largely due to State regulations, formulated in the course of the last 40 years, for the purpose of keeping poultry farmers informed in regard to breeding and management and preventing and combating diseases.

The State Institute was founded in 1904. Its purpose is the study of all kinds of diseases of livestock and poultry and the preparation of various kinds of remedies (serums and vaccines) for combating the different diseases. All advice to veterinarians and poultrymen is given free of charge.

From the beginning much attention has been paid to poultry diseases, and the examination of poultry which have died has been given gratis. This free examination is one of the principal methods of combating poultry diseases, as the value of poultry in general is too small to justify the payment of a fee for the examination of a dead bird. When he must pay for an examination, the poultryman will not send his birds in to have them examined, and in many cases expert advice is not sought until considerable damage has been done or, in serious cases of infectious disease, when neighboring farms are threatened.

The basis of the State Serum Institute is, therefore, free examination and advice, whereas the practical treatment is left to local veterinarians. In this way a centralized method of combating diseases has been formed, which is of special importance in the eradication of serious infectious diseases.

As the result of articles in poultry journals, lectures, and its own activities, the system of the State Serum Institute has become very popular in the Netherlands, for which reason serious epidemics of infectious diseases do not occur.

The distribution of vaccines and diagnostic remedies has considerably increased. As pullorum disease control on breeding and multiplication farms is now compulsory in the Netherlands by order of the Poultry Center, all poultry were tested with antigen from the State Serum Institute during last year.

The State Serum Institute is an official organization under the Veterinary Service and is always in close contact with the heads of the State Veterinary Service, veterinary surgeons, farmers, and poultrymen. Its preparations are delivered only to veterinarians. Quack remedies, which find a ready market among poultry farmers, may be sent to the institute for analysis.

STATUS OF VARIOUS DISEASES

As close contact is kept with poultrymen all over the country, a good insight is obtained on the

TABLE 1.—*Numbers of dead birds sent in for post-mortem examination*

Year	Adult hens	Chicks	Sundry birds	Total birds	Examination for pullorum disease
	Number	*Number*	*Number*	*Number*	*Number*
1929	1,985	1,378	230	3,593	154,000
1930	2,232	2,262	284	4,778	176,000
1931	2,114	2,303	254	4,671	122,000
1932	1,999	2,345	320	4,664	121,000
1933	1,909	3,180	363	5,452	151,000
1934	1,839	1,006	386	3,231	228,000
1935	1,464	1,925	450	3,839	160,000
1936	1,912	2,142	344	4,398	145,000
1937	2,301	2,688	441	5,430	216,000
1938	2,642	2,670	378	5,690	573,000

TABLE 2.—*Number of deaths, from various diseases, in adult hens sent in for examination during the last 10 years and percentage of hens affected by each disease*

Disease	1929	Proportion affected	1930	Proportion affected	1931	Proportion affected	1932	Proportion affected	1933	Proportion affected
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Klein's disease (fowl typhoid)	163	8.0	133	6.1	131	6	144	7.2	47	2.6
Cholera	8	0.5	13	0.4	7	0.3	30	1.5	27	1.4
Tuberculosis	105	5.2	97	4.4	91	4.3	80	4.0	84	4.5
Diphtheria (fowl pox)	111	5.6	137	6.1	60	2.8	63	3.1	91	4.7
Leukosis	173	8.7	195	9.0	208	9.8	126	6.3	139	7.4
Neurolymphomatosis gallinarum	59	5.0	108	4.5	186	9.0	144	7.5	194	10.3
Chronic coccidiosis	50	2.5	28	1.4	40	1.0	123	6.2	51	2.7
Diseases of the laying organs and peritonitis	481	24	530	24	528	25.2	372	19	548	29.1
Diseases of the respiratory organs	125	6.2	147	6.7	121	5.7	106	5.2	119	6.3
Sundry diseases	417	21	542	24	564	27	543	27	463	24.0
Worms	35	1.7	21	0.9	23	1.1	32	1.6	28	1.5
Tumors	17	1.0	36	1.7	36	1.6	90	4.5	56	3.0
Negative	241	12	245	11	119	5.2	146	7.5	62	3.2
Total	1,985	....	2,232	....	2,114	....	1,999	....	1,909	....

Disease	1934	Proportion affected	1935	Proportion affected	1936	Proportion affected	1937	Proportion affected	1938	Proportion affected
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Klein's disease (fowl typhoid)	53	2.0	54	3.7	34	1.8	26	1.1	18	0.7
Cholera	41	2.2	19	1.3	4	0.2	....	....	....	....
Tuberculosis	78	4.3	78	5.3	74	4.0	62	3.0	65	2.5
Diphtheria (fowl pox)	78	4.3	78	5.3	77	4.0	37	1.6	34	1.3
Leukosis	91	4.9	66	4.5	89	4.8	93	4.0	111	4.2
Neurolymphomatosis gallinarum	148	8.1	142	9.7	214	11.0	313	13.6	462	18.0
Chronic coccidiosis	118	6.5	121	8.9	310	16.3	355	15.0	355	13.7
Diseases of the laying organs and peritonitis	431	23.3	345	23.1	399	25.0	482	21.0	508	19.0
Diseases of the respiratory organs	102	5.6	85	5.8	60	3.2	42	2.0	63	2.4
Sundry diseases	509	28.0	327	22.0	458	24.0	661	29.0	703	27.0
Worms	41	2.2	21	1.6	20	1.1	13	0.6	26	1.)
Tumors	85	4.6	72	4.9	87	4.7	104	4.5	137	5.0
Negative	64	3.4	56	3.8	86	4.6	113	4.9	160	6.0
Total	1,839	....	1,464	....	1,912	....	2,301	....	2,642	....

course of various diseases. The information obtained is of great assistance in ascertaining which diseases require further investigation During the last year special attention was paid to neurolymphomatosis, as this disease, just as in several other countries, causes much damage in the Netherlands. In former years, special studies were made of fowl pest, fowl cholera, and Klein's disease (fowl typhoid), which, as shown in table 2, now never or seldom occur; and thanks to general inoculations, diphtheria (fowl pox) is no longer a menace.

Table 1 gives a summary of the post-mortem examinations made on poultry during the last 10 years.

From this table it will be seen that the number of examinations has increased considerably during the last 2 years. This fact must be attributed to the greater interest in poultry diseases in economically less favorable years and to the activities of the Netherlands Poultry Center, which instructs its officials not only to regulate breeding but also to pay attention to the health of poultry.

Table 2 gives the status of a few diseases and groups of diseases which have been found in hens during the last 10 years.

Tuberculosis, which is found in most countries but rarely in the Netherlands, has decreased considerably during recent years, owing probably to the better control on poultry farms and also to the fact that older hens are not kept. The number of leukosis cases was fairly low during the last 5 years.

The condition, however, is quite different as regards neurolymphomatosis gallinarum. The number of birds sent in for examination continues to increase and the percentages of affected birds are higher each year. This, to a certain extent, is also the case with coccidiosis. The status of these two diseases may be attributed largely to the attention that has been given to them during recent years. With regard to neurolymphomatosis special attention is paid to those cases which are not accompanied with paralysis but with emaciation, low production, and organic troubles. With regard to coccidiosis, farmers are continually warned that birds which have an abnormally pale color of the eyes and legs may be dangerous as they often suffer from chronic coccidiosis.

Diseases caused directly by worms are seldom found in the Netherlands. The percentage of deaths caused by tumors has remained at a fairly constant low level during recent years.

From this table, therefore, neurolymphomatosis and chronic coccidiosis appear to be the most dangerous diseases, and an intensive campaign against them should be carried on.

Table 3 gives the numbers of cases of tuberculosis, neurolymphomatosis, and leukosis found in each month during the last 10 years.

TABLE 3.—*Cases of tuberculosis, neurolymphomatosis, and leukosis found in the various months during the last 10 years (1929–39)*

Month	Number and proportion of cases of—					
	Tuberculosis		Leukosis		Neurolymphomatosis	
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*
January	50	3.7	135	10	120	8.8
February	62	4.8	161	12.5	90	7
March	64	4.8	124	9	65	5
April	81	6	99	7	44	3
May	90	5.5	128	7.5	50	3
June	101	5	89	4.5	107	5.5
July	99	5	74	3.7	204	9.7
August	68	3.3	65	3	263	12.5
September	61	2.6	100	4	334	14
October	43	2	95	4.5	307	14.5
November	40	2.5	110	7	222	14
December	48	3.7	100	7.7	162	13

This table shows that the number of deaths from tuberculosis is highest in the first months of summer and lowest in autumn and winter. As regards leukosis, the number of birds sent in was highest in winter and lowest in summer, whereas for neurolymphomatosis the numbers were highest in August, September, and October.

When the number of cases of tuberculosis, leukosis, and neurolymphomatosis are calculated in terms of percentage of the number of birds sent in for examination each month, the same result is obtained—tuberculosis causes the most deaths in the beginning of the summer, leukosis in winter, and neurolymphomatosis at the end of summer and in the autumn.

For these three diseases differences can also be found in the susceptibility of various breeds (table 4).

TABLE 4.—*Susceptibility of various breeds to different diseases*

Breed	Proportion of birds affected with—		
	Leukosis	Neurolymphomatosis	Tuberculosis
	Percent	*Percent*	*Percent*
White Leghorns	5.7	9.3	3.0
Barnevelders	6.5	19.8	6.3
Rhode Island Reds	6.3	8.0	8.5
Sundry breeds	8.9	8.1	5.6

Of the breeds submitted, Barnevelders and Rhode Island Reds have the greatest number of deaths from tuberculosis. The so-called sundry breeds (which include none of the utility breeds and crossings) have the highest percentage of deaths from leukosis, whereas the Barnevelders have by far the highest percentage of deaths from neurolymphomatosis.

METHODS OF COMBATING DISEASE

For combating pullorum disease, the rapid blood test, provided it is carried out by an expert and with a good antigen, gives excellent results. It is, therefore, in general practice in the Netherlands for breeding and multiplication farms. The slow blood-serum method is used in connection with the export of hatching eggs and chickens. The blood is collected by veterinarians and tested at the State Serum Institute.

As a result of long years of experimenting it was found that a mixture of fowl virus and pigeon virus gave the best results in combating fowl pox. Canary-bird virus proved to be of no value for this purpose.

No medicine was found to be suitable for combating either acute or chronic coccidiosis in chickens. Hygienic measures and diet gave good results. Preliminary tests with glycocoll proved that chickens to which this was administered grew better than others. Hens which are greatly infected can be improved and caused to lay only by feeds rich in vitamins, protein, and minerals. In my opinion, the reason is that such birds digest a much smaller quantity of their feed than do normal birds. To keep the flock from becoming affected, however, it is absolutely necessary that all birds which show symptoms should be completely isolated and slaughtered directly after they have ceased laying. These birds can usually be detected from the noticeably pale color of legs and eyes, emaciation, and poor production.

Laryngotracheitis has not yet been found. All suspected cases have proved to be caused by fowl pox virus.

After lengthy experiments carried out in various ways it has not been proved definitely that a virus plays a part in neurolymphomatosis. In my opinion neurolymphomatosis and leukosis may be due to various causes. The various degrees of susceptibility in different breeds and the difference in the time at which the disease is found to be most prevalent should be taken into consideration. It is possible that in different countries the causes of neurolymphomatosis vary. Remedies, such as hypervitaminizing and treatment with vitamin E have not been successful in cases of neurolymphomatosis. The combating of this disease must be carried out chiefly by the breeder by using hens more than 1 year of age which are resistant.

With regard to the connection between affection of the eyes and diseases, in the years 1936, 1937, and 1938 it was found that of the 6,855 dead birds sent in for examination 357, or 5.2 percent, had affected eyes. In dead birds which are partially decomposed it is often impossible to give an exact report concerning the eyes. Of these 357 hens, 76 had died of neurolymphomatosis; 49, of chronic coccidiosis; 48, of diseases of the laying organs and peritonitis; 28, of tumors; 18, of inflammation of the intestines; 13, of leukosis; and 96, of 10 other diseases. A correlation between eye lesions and diseases other than neurolymphomatosis was not determined although it is noteworthy that such lesions were chiefly found in birds dead of paralysis, chronic coccidiosis, and diseases of the laying organs and peritonitis.

Tests carried out in 1937 and 1938 proved that the death rate is high among birds in which lesions of the eyes were discovered at an early age. It is, therefore, inadvisable to keep such birds and they certainly should not be used for breeding. The highest percentage of birds with eye lesions was found in January to June.

I advise the following for the prevention of poultry diseases: (1) Breed from healthy birds more than 1 year old; (2) feed adequate diets, and (3) practice sanitation. For the combating of poultry diseases, a free examination of dead birds at a central official laboratory is desirable.

The combating of poultry diseases should be completely in the hands of veterinarians. The task of the institute should consist in the study of diseases and the methods of combating them both at the institute and in general practice, in the preparation of remedies, and in extensive propaganda.

SUMMARY

In spite of the large number of poultry in the Netherlands the death rate is low. Poultry which have died from disease are examined free of charge at the State Serum Institute at Rotterdam. Advice is given gratis. Diagnostic remedies and other preparations (vaccines and serums) are distributed only among veterinarians.

Free examination is one of the principal methods of combating poultry diseases in the Netherlands. When the poultryman must pay for an examination, he seldom has it done and in many cases expert advice is not sought until considerable damage has been done.

From examinations made at the Institute, it has been found that neurolymphomatosis and coccidiosis are increasing among poultry and therefore are dangerous diseases. In former years, fowl pest, fowl cholera, and fowl typhoid were rather prevalent but at present they seldom occur. Fowl pox, as a result of general inoculation, is no longer a menace. Both tuberculosis and leukosis are decreasing.

Poultry diseases must be combated by the breeding of highly resistant birds, which must be kept under hygienic conditions and fed adequate diets.

INFECTIOUS DISEASES OF FOWLS IN ITALY

By Prof. Carlo Bisanti, *Minister of the Interior, General Director of Public Health, Rome, Italy*

In Italy the official report of the existence of fowl cholera, fowl plague, and fowl diphtheria is mandatory.

None of these infectious diseases are widespread, as is shown in table 1 for the years 1935–37. Besides these infectious diseases, there were some cases of typhoid which, however, never spread far.

The sanitary measures of the Veterinary Service are applied by the veterinary surgeons of the provinces and of the municipalities, with the assistance of the experimental zooprophylactic stations. If necessary, these stations make diagnostic investigations by laboratory researches. They have been especially useful, in accordance with the regulatory measures of the Ministry of the Interior, in the diagnosis of pullorum disease by means of the blood test on all those poultry farms which were authorized to distribute material for the improvement of livestock in Italy.

The work of the authorities in the protection of national poultry breeding against infectious diseases has chiefly consisted in the application of the sanitary precautions issued in the veterinary regulations approved by the Royal Decree, No. 533, of May 10, 1914, and also in the ever-increasing administration of prophylactic measures against those infectious diseases to which this regulation is applicable.

It may be of interest to give a brief outline of the precautions established by the veterinary regulations, both by the communal and the prefecture authorities.

TABLE 1.—*Occurrence of infectious diseases in Italy, 1935–37*

Disease	Cases in the year—		
	1935	1936	1937
	Number	*Number*	*Number*
Fowl cholera	632	190	231
Fowl plague	83	44	57
Fowl diphtheria	38	46	32

PRECAUTIONS TAKEN BY THE COMMUNAL AUTHORITIES

On receipt of information of an infectious poultry disease, the authorities order the following: (1) Isolation of the sick birds and of those suspected of harboring the disease, when the owner does not prefer to kill them; (2) thorough disinfection of the places where these sick birds have been kept and of everything with which they have come into contact; (3) quarantining special enclosures, of the healthy birds that might have been exposed to the infected birds.

PRECAUTIONS TAKEN BY THE PREFECTURE

The Prefect, on being informed by the communal authorities of the outbreak of an infectious disease, issues a decree stating that the zone is infected, and in addition to the previously mentioned sanitary measures orders the following: (1) Registration of all fowls in the infected zone and also an indication of the limits of the said zone and a notice bearing the name of the disease; (2) a prohibition of said fowls drinking from any reservoirs or other sources that communicate with watercourses; (3) a prohibition of their transfer from the poultry house; (4) the suspension of conducting poultry sales within a given distance from the infected area; (5) the immunization of the birds if possible.

Further, the prefectural decree may order that (6) the sick birds be killed and destroyed; (7) the birds suspected of having the disease be killed, in which case the flesh of such birds may be eaten in the infected area only and the intestines, feathers, etc., must be destroyed; (8) the dovecots in the infected zone and in the neighboring territory must be kept closed; (9) any cages, boxes, etc., cannot be removed, unless they have been previously thoroughly disinfected according to specific instructions.

All these sanitary precautions are kept in force as long as the epizootic is raging, and the prefectural decree with regard to the infected area is not revoked until 15 days have elapsed after all the birds have been killed without any further case of the disease manifesting itself. In the whole infected zone very thorough disinfections are performed.

PRECAUTIONARY MEASURES FOR IMMUNIZATION OF FOWLS

The normal veterinary precautionary measures, everywhere intensively applied, have largely consisted, during the last 3 years, in the use of a treatment for immunizing the birds against fowl cholera and the rare manifestations of typhoid.

A special fund has been allotted to the Prefectures for the purchase of biological products for rendering the birds immune. These biological products are distributed at a low cost to the breeders and sometimes are even supplied free of charge. Educational work has been pursued for the promotion of such a prophylactic program.

The biological products for immunizing the fowls have been supplied by the National Institute of Serum Producers and in great part by the zooprophylactic stations which, in some cases, have also prepared with benefit autogenous vaccines.

SUMMARY

In Italy the official reporting of the existence of fowl cholera, fowl plague, and fowl diphtheria is mandatory.

From 1935 to 1937, inclusive, none of these infectious diseases have been widespread.

The sanitary measures of the Veterinary Service are applied by the veterinary surgeons of the provinces and of the municipalities, with the assistance of the experimental zooprophylactic stations.

The measures taken by the communal authorities and by the Prefectures for the protection of poultry farming consist chiefly in the isolation or destruction of sick and suspected birds, the thorough disinfection of the premises and equipment with which the sick and suspected birds might have come in contact, the quarantining of the healthy birds, and the immunization of healthy birds. These measures can be completed by prohibiting the importation and exportation of fowls in the infected and suspected areas and by similar hygienic precautions.

All these sanitary measures are kept in force as long as the epizootic is raging and are not revoked until 15 days have elapsed after all the sick birds have been killed and no further case of the disease has manifested itself.

IMPORTANT DISEASES OF POULTRY IN EGYPT AND THEIR CONTROL

By DR. HAFEZ SHARAF EL-DINE, *Subdirector of Veterinary Pathological Laboratory, Veterinary Service, Ministry of Agriculture, Dokki, Egypt*

In Egypt, where the number of chickens annually hatched in the Egyptian Baladi incubators exceeds 75,000,000, poultry keeping is a highly profitable industry and is mainly carried on by "Fellahas" or country women. The valuable experience they have gained through generations has endowed them with considerable skill in poultry keeping, and though they do not follow any scientific method of breeding, yet they are greatly helped by the excellent climatic conditions and the highly productive soil of the country. The same conditions of climate and soil seem to be favorable for the spread of infectious diseases, particularly since the birds are given out-of-door liberty on the farms and in the villages. This lack of confinement is an important factor for the spread of different diseases in the country.

The important infectious diseases of poultry in Egypt are fowl plague, fowl cholera, fowl typhoid, bacillary white diarrhea, fowl diphtheria, fowl pox, spirochetosis, and piroplasmosis.

FOWL PLAGUE

Fowl plague is the most prevalent infectious disease of poultry in Egypt at the present time. Owing to its infectivity and the fact that it is very widespread, it causes a high percentage of mortality particularly during the spring months, which seem to be the most favorable time for the spread of the infection. The disease manifests itself in the peracute, acute, or subacute form and produces severe infection which usually ends in death. In some cases, however, when the disease shows slight clinical manifestations recovery may occur.

As a prophylactic measure fowls are inoculated with the vaccine to obtain immunity.

FOWL CHOLERA

Fowl cholera is another serious disease causing high mortality. It has greatly diminished in extent and even seems to have disappeared from the country. The disease usually occurs in the acute form but sometimes takes a severe, peracute course, as a result of which the bird drops dead without showing any symptoms. Some cases may recover if the disease occurs in the chronic form.

Anti-fowl-cholera serum is used as a curative treatment for this disease, whereas the vaccine is used as a prophylactic measure to obtain immunity.

FOWL TYPHOID

Fowl typhoid may be mistaken for fowl cholera. The disease mainly affects chickens and turkeys and has been reported in peacocks but has never been seen in pigeons, geese, or ducks. It usually manifests itself in the acute or chronic form.

A vaccine is used to confer immunity against fowl typhoid.

BACILLARY WHITE DIARRHEA

This disease is fairly widespread especially in foreign breeds and crossbreeds. It causes heavy losses in young chickens. Diagnosis is made by the Veterinary Pathological Laboratory. The stock of the State poultry farms are tested annually and reactors are killed and sold.

FOWL DIPHTHERIA AND FOWL POX

These are fairly widespread diseases in Egypt. A high percentage of affected birds recover after treatment, but death sometimes occurs after a few weeks, and in foreign breeds fatal termination may occur in a much shorter period.

A special vaccine prepared by the Veterinary Pathological Laboratory is used as a safeguard against these diseases.

SPIROCHETOSIS AND PIROPLASMOSIS

These are conspicuously prevalent in summer in Egypt.

The organism producing spirochetosis among geese was first demonstrated by Sakharoff in 1890 in Transcaucasia and was called *Spirochaeta anserina*. Later, in 1903, Marchoux and Salimbeni observed a similar organism in fowls in Brazil, which has been called *S. gallinarum*. The two parasites seem to be identical, and subsequent morphological and biological observations have not proved them to be a separate species.

Carpano, in 1928, made a thorough study of the parasite producing piroplasmosis in fowls in Egypt—a disease previously confused with spirochetosis—and called it *Aegyptianella pullorum*. This organism is an intracorpuscular parasite generally occurring within the cytoplasm of the red cells. It varies in size from 1 to 3 and rarely to 4 microns. As a rule one or two parasites, occasionally 5, and rarely 6, may be seen attacking a red cell. In 1933, the writer observed piroplasmosis in geese but could not notice any difference—either morphological or biological—between the parasite seen in geese and the *Aegyptianella pullorum* usually encountered in fowls, and until it is proved to be a different form the nomenclature *A. anserina* would not be appropriate. In the study of the causative parasites in geese, they were not seen lying free in the plasma. In fresh blood preparations they appeared as small, round, colorless bodies in the cytoplasm of the red cells and were capable of moving slowly from one place to another within the corpuscles. In stained preparations the parasites did not take the stain uniformly. They varied in size from 1 to 3 or 4 microns. The small forms were round and deeply stained. The larger forms were oval, round, or pear shaped, showing a central protoplasmic mass with a chromatin nucleus resembling a signet or an incomplete circle. In most cases one or more parasites were found in a single red cell. However, as many as 8 or 10 parasites were occasionally seen in one cell (fig. 1). In piroplasmosis the number of red cells attacked sometimes reach large proportions, particularly in foreign breeds or selected crossbreeds. In one of the infected im-

FIGURE 1.—Blood smear from goose, showing infection with Aegyptianella-like organisms.

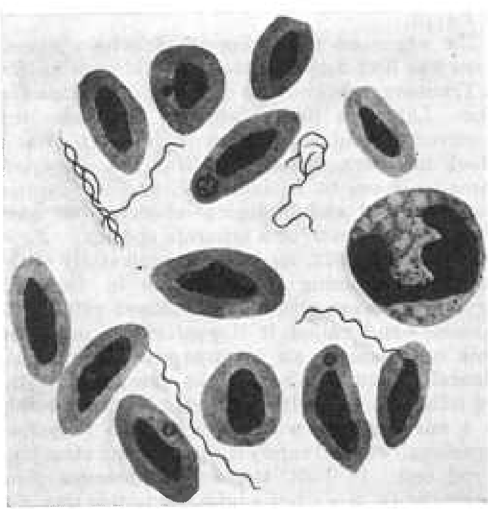

FIGURE 2.—Blood smear showing *Aegyptianella pullorum* and *Spirochaeta gallinarum*. (After Carpano.)

ported fowls, 10 percent of the red cells were infected with one or more parasites.

Most chickens, geese, and ducks, particularly those bred on sandy soil (which is the most suitable ground for ticks) are infected with one or both of these diseases (fig. 2). Infection may be either chronic or acute and causes heavy losses particularly in foreign and selected crossbreeds of chickens and also in ducks and geese. Native domesticated birds usually resist infection probably because of repeated previous attacks or inherited immunity. They may not show any symptoms if infection remains latent. As a curative treatment the injection of 0.01 gram per kilo of body weight of either atoxyl or neosalvarsan has proved to be effective. Spirocid sodium tablets given per os are used as a prophylactic and curative treatment. Spraying tick-infested premises with Cooper's Garrapaticida is essential to avoid another infection.

STATE MEASURES FOR COMBATING POULTRY DISEASES

To reduce the losses from these diseases, the Director of the Veterinary Service, Dr. Ahmed Farid Bey, assisted by his staff, has launched a campaign against the spread of infection.

A special quarantine service for controlling arrivals of poultry from Upper Egypt exists in Giza.

Numerous pamphlets and articles on poultry diseases have been written, some have been broadcast, and extensive propaganda has been carried on to draw the attention of the breeders to the ravages of the infectious diseases and to the sanitary precautions and prophylactic measures which should be taken. The Poultry Breeding Section and the Veterinary Pathological Laboratory are always ready to forward, free of charge, available information.

All vaccines and serums against poultry diseases prepared by the Veterinary Pathological Laboratory are furnished free to owners on request. Moreover, the Director of the Veterinary Service is always ready to send a veterinary surgeon to diagnose, inoculate, and give directions for isolation and disinfection. For confirming diagnosis, blood smears and swabs or the head and the femur of a dead bird are sent to the Veterinary Pathological Laboratory either by the veterinarian or by the owner. All such measures, together with the necessary advice and instructions, are provided free of charge.

Bird markets are carefully inspected by veterinary surgeons. Sick birds and those which have been in contact with sick birds are isolated and kept under observation to prevent their being exhibited for sale or transported to other places. The infected premises are thoroughly disinfected and left vacant for 3 weeks before any new birds are admitted.

Such precautionary measures, together with vaccination, have given favorable results and lessen the ravages of infectious diseases.

SUMMARY

In Egypt, where more than 75,000,000 chickens are hatched annually, the industry is mainly carried on by women. The climate and soil of the country are favorable for both poultry breeding and poultry diseases.

Fowl plague is the most prevalent disease in Egypt. Fowl cholera seems to have disappeared.

Fowl typhoid is not so prevalent as some of the other diseases. Bacillary white diarrhea, fowl diphtheria, and fowl pox are fairly widespread.

Spirochetosis and piroplasmosis are particularly prevalent in summer. The causative parasites of spirochetosis in chickens and geese are very similar. *Aegyptianella pullorum* is the name given by Carpano in 1928 to the piroplasma in fowls. In 1933 the author observed piroplasma in geese but did not find any difference between this parasite and *A. pullorum.* Atoxyl, neosalvarsan, and Spirocid sodium tablets are used for treatment of spirochetosis and piroplasmosis.

To reduce the losses from these diseases the measures taken by the veterinary service are as follows: Setting up a quarantine service at Giza; providing vaccine and serums for prophylactic treatment; writing and distributing pamphlets and articles on diseases of poultry as well as broadcasting such information; forwarding information relating to poultry by the Poultry Breeding Section or the Veterinary Pathological Laboratory; providing the service of veterinarians for diagnosing diseases, inoculating birds, and supervising isolation and disinfection. This service, together with making the agglutination test in the Veterinary Pathological Laboratory, is free of charge. The results obtained are very favorable.

DISEASE PROBLEMS OF LONG ISLAND DUCK RAISERS

By DR. K. F. HILBERT, *Poultry Disease Laboratory,*[1] *Farmingdale, New York, U. S. A.*

On Long Island the duck-raising industry is of considerable importance. Many of the establishments or "ranches" market annually from 50,000 to 350,000 birds. Most of them operate on comparatively small areas of ground and the sanitary conditions leave much to be desired.

The marketable product is the ducklings, which are dressed for the trade at from 10 to 12 weeks of age, when they weigh from 5 to 7 pounds. The greatest number of ducklings are hatched during February, March, April, and May. Hatches consist of 2,000 to 5,000 or more.

Disease losses on these duck ranches often are very large. They have reached 30,000 on a single ranch in not more than 2 weeks. The losses are largely in ducklings in which the unit value is not high, but the breeder flocks are by no means exempt. All in all, it is doubtful whether any other animal-raising business is subject to such a large percentage of mortality as this one.

The production methods, by which very large numbers of young birds are herded together, naturally favor the spread of infection. The feeding of many birds in open flats and the presence of exceedingly large numbers of flies also favor the spread of infection.

The greater part of the disease losses on these establishments is caused by two septicemic diseases, of which fowl cholera caused by *Pasteurella avicida* is most common. The disease described by Hendrickson and Hilbert in 1932 (*2*),[2] now commonly called *anatipestifer* infection, causes disastrous results on a few duck ranches each season. Anatum infection (Keel) causes small losses occasionally, especially when complicated with rickets. Aspergillosis and rickets account for a few losses each season, as does botulism. Parasitism, except for occasional infestations of lice and red mites, is extremely rare.

FOWL CHOLERA

Fowl cholera (hemorrhagic septicemia) is an infectious and contagious disease of ducks, chickens, turkeys, pigeons, geese, cage birds, and wild birds, caused by *Pasteurella avicida.* Many outbreaks in ducks follow adverse weather conditions, insanitary conditions, overcrowding, and poor ventilation. The disease is characterized by sudden deaths and high mortality. In ducks it is usually acute but is sometimes subacute or chronic.

Symptoms, course, and mortality.—The symptoms resemble those in cholera of chickens. They include increased thirst, loss of appetite, depression, nervous twitching, elevation of temperature, watery eyes that later become incrusted with dirt, and a whitish mucous discharge from the bowels that later becomes yellowish and then greenish and watery. The legs and neck are hot to the touch. The breast muscles are congested, and the skin appears pinkish. The nostrils often contain a slimy or gelatinous exudate. Swollen feet or joints are usually seen in at least a few ducks in each outbreak.

The course of the disease is acute in most cases, losses up to 90 percent occurring in a week to 10 days. Those running a chronic course are usually found to have localizations in the joints or air sacs. These birds become emaciated but may live for weeks.

Autopsy findings.—The autopsy findings in ducks are typical of those in chickens although usually more pronounced. The heart is often enlarged and studded with pinpoint hemorrhages, especially in the coronary fat. The pericardium may be thickened and often contains a yellowish fluid and from a few to many yellowish flakes. In

[1] Maintained by the New York State Veterinary College at Cornell University in cooperation with the New York State Institute of Applied Agriculture, at Farmingdale.

[2] Italicized numerals in parentheses refer to Literature Cited, p. 233.

ducklings the air sacs are usually clouded. Pinpoint hemorrhages may also be found on the lining of the body cavity, gizzard fat, and in the liver. The liver is slightly swollen, friable, and sometimes contains minute whitish areas that give it a mottled appearance.

The nasal sinuses are usually congested and frequently contain a gelatinous exudate. The lungs, if changed at all, are congested; occasionally pneumonia is present. The intestines are slightly to severely hemorrhagic, and the contents are semiliquid to mucoid in consistency. The feces are yellowish or yellowish green. The blood vessels of the mesentery and intestines are usually engorged with blood. Practically all the muscles are congested and appear darker in color than normal. The spleen and kidneys show from a slight to well-marked swelling.

In the chronic form of the disease, affected joints may contain a reddish serous, whitish creamy, or yellowish cheesy exudate. The air sacs are usually thickened and contain large quantities of yellow cheesy exudate. Birds affected with this form of the disease are always emaciated.

Diagnosis.—Although the history, symptoms, and lesions may indicate the disease, bacteriological examination is necessary for a positive diagnosis. Fowl cholera must be differentiated from such acute diseases as *anatipestifer* infection and from poisoning. The color of the feces can not be considered an aid to diagnosis.

Prevention and treatment.—As shown by Hilbert and Tax (*4*), chemically killed autogenous bacterin is a means of controlling this disease even when the birds are kept under the insanitary conditions that prevail on the ordinary duck ranch. The bacterin is injected subcutaneously, 1 cc being used for ducklings and 2 cc for older birds.

Skidmore's observations (*5*) on the common house fly as a possible carrier emphasize the need of prompt disposal of sick and dead birds. Burning instead of burial is preferable; otherwise the diseased carcasses that are capable of harboring viable cholera organisms for at least 11 days at room temperature and for at least 2 months at icebox temperature, as shown by Hendrickson and Hilbert (*3*), may be dug up by dogs or other animals and thus serve as an additional source of infection. Sanitation plays an important role in control, but unfortunately it seems almost impossible to obtain what would be considered good sanitation on a duck ranch.

The only treatment that appears to have any value is the injection of large quantities of antihemorrhagic septicemia serum (15 to 20 cc). This treatment appears to save about 50 percent of the affected birds, but because of the cost per duckling and the additional time required to obtain a marketable size and weight, disposal of the sick birds appears to be more desirable.

ANATIPESTIFER INFECTION

Anatipestifer infection is a highly infectious disease of young ducks caused by *Pfiefferella anatipestifer*. The disease is acute, death occurring frequently in 6 to 12 hours after symptoms are first noticed. A few birds may develop a more chronic disease that terminates in death after several days. This disease was first described by Hendrickson and Hilbert (*2*) in 1932. A disease similar if not identical was described by Graham, Brandly, and Dunlap (*1*) in 1938.

Symptoms.—The first symptom of this disease is depression, manifested by a sleepy attitude and ruffling of the feathers. There is a severe diarrhea. The discharges are of a distinctly greenish color. The affected birds are soon unable to stand and there is a continuous bobbing and jerking of the head. The birds often have a serous discharge from the eyes. Later complete prostration occurs; the birds lie on the ground or floor of the pen unable to raise their heads.

Lesions.—The lesions are those of a rapidly developing septicemia. Petechial hemorrhages are commonly found on the serous surfaces of the liver, heart, and body wall. In nearly all cases the conspicuous lesion is a yellowish edematous exudate consisting of fibrin that covers the liver and adheres closely to it so that it can be removed only with difficulty. A similar exudate causes adhesions of the pericardium to the heart wall. The coronary fat and the tip of the heart are sometimes edematous. The spleen is usually slightly enlarged and presents a peculiarly brown and white mottling. The kidneys are usually congested. Most birds exhibit a severe hemorrhagic enteritis. Large quantities of blood-stained exudate are found on the intestinal mucosa. The lungs are usually highly congested and occasionally consolidated. The blood is dark in color and often uncoagulated.

Diagnosis.—The yellowish fibrinous exudate covering the liver and heart is suggestive, but diagnosis must rest primarily on isolation and identification of the causative agent from the blood and internal organs of ducks dead of the disease.

Treatment and control.—Treatment is of no avail. Experimental work indicates that a chemically killed bacterin may be an aid in the control. Production of such a bacterin appears to be impractical at the present time as the organism grows so poorly that it can be made only at a prohibitive cost. Rigid sanitation and the destruction of all visibly sick ducks seem to offer the best means of control at the present time.

SUMMARY

The duck raising industry on Long Island is of considerable importance. Many ranches market from 50,000 to 350,000 ducks annually. Losses due to disease are often extremely high. Most of these losses are caused by fowl cholera and *anatipestifer* infection. Of these, cholera is the more important.

Fowl cholera is a septicemic disease caused by *Pasteurella avicida*. Symptoms resemble those seen in chickens. The course of the disease is

acute, losses up to 90 percent occurring often in a week to 10 days. Those running a chronic course are thin in flesh and often are lame, having swollen feet or joints. Autopsy findings are those of a septicemia. Severe hemorrhagic enteritis is usually present. The muscles are congested and dark in color. Affected feet and joints contain reddish serous, whitish creamy, or yellowish cheesy exudate. Affected air sacs are thickened and contain much cheesy exudate. Positive diagnosis rests primarily on bacteriological examination. Treatment except for extremely large doses of anti-hemorrhagic septicemia serum is of no value. Chemically killed autogenous bacterin is a means of control. Prompt disposal of dead birds by burning is important.

Anatipestifer infection is a highly infectious disease of young ducks caused by *Pfiefferella anatipestifer*. Death often occurs within 6 to 12 hours after symptoms are observed. Symptoms are those of depression, which lead to complete prostration. Continual bobbing and jerking of the head are seen. The lesions are septicemic in character. One of the most prominent lesions is a fibrinous exudate covering the liver and heart. This exudate adheres closely to the organs. The lungs are congested, sometimes consolidated. Hemorrhagic enteritis is a prominent lesion. Diagnosis must be made by isolation of the causative organism. Treatment is of no avail. Control at the present time lies in strict sanitation and disposal of sick and dead birds by burning. Experimental work indicates that a bacterin may be an aid to control.

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PARATYPHOID IN DUCKS IN RELATION TO PUBLIC HEALTH

By Dr. A. Clarenburg, *Chief of the Veterinary Sub-Department of the National Institute for Public Health, Utrecht, Netherlands*

During the last few years the problem of paratyphoid in ducks has generally drawn attention, both in scientific periodicals and in the nonprofessional press. This fact is due to a great number of food poisonings in man, with symptoms of an acute gastro-enteritis caused by the consumption of duck's eggs. For a long time it has been known that paratyphoid occurred in ducks. Little attention was paid to this disease, which was not very important from an economic point of view. Because of its dangerous influence on public health, however, the sale of duck's eggs threatens to decline considerably, as a result of which duck breeding will be seriously damaged.

Consequently, first and foremost, attention should be paid to fighting the danger to man. Next, measures should be taken to combat the disease among ducks as much as possible.

Paratyphoid of ducks, as with birds in general, is a disease of the young. Young ducklings especially, sometimes a large percentage of them, are victims of the disease. Those that live suffer from diarrhea, as a result of which many paratyphoid bacilli are secreted; and thus the disease is spread.

Because of the bacterial contamination of the eggs, embryos may die or the ducklings, when hatched, are infected. The latter have an insufficiently resorbed yolk-residue in contrast to that of healthy ducklings (according to Jansen). In the post-mortem examination of fowls which have died, a catarrhal enteritis together with a degeneration of the parenchymatous organs will be observed. The disease can be diagnosed by means of a simple bacteriological examination. The causative paratyphoid bacilli are easily recovered in great numbers from all organs.

The adults appear to be far less sensitive to acute infection with the paratyphoid bacilli; therefore, as a rule, the disease has a chronic character. In this case diarrhea, emaciation, and listlessness may be observed, but for the most part no symptoms will be seen.

From the standpoint of public health, the following are of considerable importance.

1. In affected birds the paratyphoid bacilli are often localized in the sexual organs. In the female bird, the ovary especially and also the oviduct are affected. In the male bird, the infection in the testicles may cause the eggs to have a bacterial infection.

2. Paratyphoid bacilli may be secreted with the feces of affected birds even though they appear healthy from the clinical point of view. In addition contamination of the eggshells is possible.

In the post-mortem examination of adults we often observe, as the only lesion, a chronical oöphoritis, in which case degenerated ova may be observed by the side of normal ones. The former have an irregular shape and a dry, doughy consistency, and they are often connected with the ovary by means of a long thin fiber of tissue. Moreover, the birds may be emaciated and show catarrhal enteritis, but in many cases there are no pathological changes. The lesion of the ovary mentioned is not pathognomonic, as it is also observed at times in ducks which are not suffering from a paratyphoid infection.

By means of a thorough bacteriological examination, the diagnosis may, as a rule, be ascertained. Mostly, paratyphoid bacilli can be shown in only one or several organs. In connection with the bacteriological examination, attention should be paid to the following:

1. The ovary should always be included in the examination, as paratyphoid bacilli are often found exclusively in this organ. Both normal and degenerated follicles should be examined, as the former may also contain paratyphoid bacilli.

2. Particularly with birds which have been killed, but also with birds that have died, large amounts of the organic tissue should be cultured. I have often found, after having examined other kinds of animals, that media inoculated with a small amount of organic material that had been seared with a hot spatula remained sterile, whereas in media inoculated with a larger quantity, a growth of paratyphoid bacilli could be observed. Probably these bacilli are distributed either sparsely or irregularly, or both, in the organs.

In the living animal, first and foremost, the blood should be examined by the agglutination test, and the feces should be subjected to a bacteriological examination. It must be pointed out emphatically that even after repeated application of the two methods, not all infected fowls can be detected, which fact has also been shown by other investigators, (Wanner, for example). Next, eggs may be examined, both contents and shell being included. The eggs of infected ducks are only sporadically infected by paratyphoid bacilli; therefore, a great number of them should be examined. As a result, much of the practical value of this examination is lost. In examining the contents of the eggs, an enrichment method should be applied, since as a rule a small number of paratyphoid bacilli can be shown in them. The enrichment cultures must be in the incubator 3 days at least.

The paratyphoid bacilli which are found in ducks chiefly belong to the Aertrycke type (*Salmonella typhi murium*) and Gaertner type (*S. enteritidis* var. *essen*). Besides, *S. anatum* is found in America, which at this writing has not been observed in Europe, so far as I know. These three types are all pathogenic for man.

In the Netherlands, the Gaertner type occurs more frequently than the Aertrycke type, at least according to my investigations. The two types can often be found in the same duck breeding establishment. Concerning the biological characteristics, according to the literature a rhamnose negative reaction is characteristic of the Aertrycke bacilli of ducks, as reported by Herrmann and others; a delayed dulcitol fermentation is characteristic of the Gaertner bacilli, according to Müller and Rodenkrichen and others. Some investigators—Edwards, Wanner, and Wesselmann—report a rhamnose-positive reaction of the said Aertrycke type. While examining 130 Aertrycke cultures I always observed, with one exception, a considerably delayed rhamnose fermentation (as a rule, negative after 4 days); in the case of some cultures, positive after 3 days; and in 70 Gaertner cultures I observed in all cases a delayed dulcitol fermentation (negative after 24 hours, positive after 2 days). In the few cases in which I obtained a different result, the cultures in question did not appear to be pure. So far, I observed a rapid dulcitol fermentation (within 24 hours) with Gaertner bacilli, cultured from other kinds of animals (cow, calf, pig, sheep, guinea pig, rat, and mouse), whereas I saw a delayed rhamnose fermentation also with some Aertrycke cultures from a foal and a sheep. Jansen cultivated rhamnose negative Aertrycke cultures from a rat, gull, monkey, and some aviary birds. It is possible, however, that in the case of these rhamnose-negative Aertrycke cultures the infection may have been transmitted by ducks.

Next to the antigenic analysis according to the Kauffmann-White principle, this simple, cultural investigation has, in various cases, proved to be a valuable indication for tracing the source of infection in the case of food poisonings. Moreover, it is a contribution to the knowledge of the epidemiology of paratyphoid in ducks.

As to the frequency of paratyphoid in ducks, we may assume, on account of numerous publications in various countries and from the results of my own investigations, that the disease is rather widespread, although exact, positive facts are lacking.

The danger to public health is almost exclusively due to the consumption of infected eggs insufficiently cooked. An infection caused by contact with sick ducks very rarely occurs, according to Charlotte Ruys. Furthermore, there is practically no danger from eating duck's flesh because paratyphoid bacilli, if any, are killed during the cooking process. Nothing has been stated so far on the cause of food poisonings owing to thermostabile toxins.

Though exact figures can be obtained only from the most extensive investigations, it may be assumed from the literature and also from my own investigations that at least 1 percent of the duck's eggs on the market contain paratyphoid bacilli; besides, one may expect the percentage of the infected eggshells to be much higher.

Therefore, with a view to their danger to public health, much attention should be paid to infected duck's eggs, the more so as one egg may cause many cases of illness.

The consumption of fresh duck's eggs, as such, is not very dangerous, since as a rule there are few bacilli in them, and also on the shells their number will be small. Experience has shown that for food poisoning in general, a great number of paratyphoid bacilli is necessary. As duck's eggs which have been conserved in lime water usually contain a greater number of paratyphoid bacilli than do fresh eggs, the consumption of the former is more likely to cause illness. The greater number of bacilli in these eggs is not caused by the penetration of paratyphoid bacilli via the eggshell during conservation, as has been stated by Lerche, but rather by an increase of the paratyphoid bacilli in the eggs after the latter have been taken from the lime pits. From recent experiments I have found, that in our country the lime water which is used for the conservation of the eggs is strongly germicidal, so that paratyphoid bacilli are killed within a few hours. I may add that this lime water is a saturated solution, which always results in the constant presence of solid calcium hydroxide. The lime pits are underground, thus assuring a low temperature. Great care is taken that a sealing pellicle consisting of calcium carbonate forms on the lime water.

What is most dangerous, however, is the use of infected duck's eggs in preparing food which is not sufficiently heated to kill paratyphoid bacilli, so that these germs may multiply with facility and toxins may be formed. From this standpoint the contamination of eggshells, according to Lerche, is insignificant. Many kinds of food—cake, mayonnaise, pudding, minced meat, etc.—have caused food poisonings. Attention should be paid to ice cream, which has caused a widespread poisoning in Holland—60 cases, according to de Koning.

Regular veterinary control of duck farms is necessary to combat paratyphoid in ducks. In addition to hygienic measures, a serological examination should be applied and the birds which react must be removed. In this way, there will be a check on the high poultry mortality, and the number of infected birds will be decreased. Moreover, feces and eggs should be examined bacteriologically.

Concerning the serological examination, the application and judgment are different with various investigators. With the antigenic structure of paratyphoid bacilli as a basis, separate reactions with the different O (somatic) and H (flagellar) antigens should be applied. So far as I know, this procedure has not yet been carried out. It would be desirable to experiment in this direction, as thus a more appropriate and uniform method will be possible.

With the measures mentioned, many infected birds cannot be detected; therefore, there is still the danger of the contaminated eggs, though in a lesser degree. This fact was demonstrated to me, for example, from an investigation of 600 eggs from nonreacting ducks, of which I found 10, or 1.7 percent, to be internally infected with paratyphoid bacilli. Of 200 eggs of reacting birds from the same farm and separated from the former group, the number infected was 12, or 6 percent. Therefore, it is not to be wondered at that in the literature some food poisonings are mentioned, which have resulted from the consumption of eggs from a farm that has been controlled (Goerttler). It is now recommended that eggs from nonreacting birds be examined for paratyphoid bacilli (Zwanenburg). Aside from the practical objections, it is doubtful whether the results desired will be obtained with this method.

As the protection to public health against the paratyphoid bacilli cannot be guaranteed by any method, we depend for the time being on measures taken by the Government regarding the trade in duck's eggs. Goerttler also pointed out the desirability of legal measures. In our country this matter has been settled effectively by two regulations of June 13, 1938. According to these, the use of duck's eggs is not allowed for preparing foods and drinks, neither are they allowed to be on the premises where these are prepared. Besides, duck's eggs available for consumers must bear a distinctly legible and durable stamp: "Duck's egg—boil 10 minutes." It seems reasonable that for the preparation of products such as biscuit, which certainly will be sufficiently heated, exemption from the above regulations may be granted. In conclusion, I wish to draw attention to egg products of which there are various kinds and large quantities in the trade, such as frozen "whole egg" (mixture of yolk and white) and liquid yolk. If no particular precautions during preparation are observed, in processing these materials there will be danger to the public health. In my opinion it would be most advisable to institute inspections which may lead to the destroying of paratyphoid bacilli, if any, in the products mentioned, without impairing their usefulness. In this way not only hygienic but also great economical interests will be served.

SUMMARY

Paratyphoid in ducks is of foremost importance in connection with public health. Directly economical interests, involving mortality especially among young ducklings and decreased production of eggs, are of secondary importance. In contrast to the young birds, the adults are far less sensitive.

As to public health, the localization of the infection in the ovary and the excretion of paratyphoid bacilli with the feces are of special importance, since the eggs may thus be infected internally and externally with paratyphoid bacilli.

Especially the Aertrycke type (*Salmonella*

typhi murium) and the Gaertner type (*S. enteritidis* var. *essen*) should be considered as causing infection in ducks, whereas in America *S. anatum* is also found. These three types are all pathogenic for man. A negative or delayed rhamnose fermentation is characteristic of the Aertrycke type; a delayed dulcitol fermentation, of the Gaertner type.

Paratyphoid is rather widespread among ducks. At least 1 percent of the eggs is internally infected with paratyphoid bacilli, whereas it may be assumed that there is a higher percentage of contaminated eggshells.

The danger to public health is almost exclusively in consumption of food, prepared with the infected eggs, which is heated insufficiently or not heated at all.

In combating the disease among ducks, a serological examination should be the first consideration.

In fighting the danger to public health, we depend for the time being on legal measures regarding the trade in duck's eggs.

I recommend the study of the following problems: (1) Serological examination by the use of the various necessary O (somatic) and H (flagellar) antigens; and (2) preparation of egg products free from living paratyphoid bacilli.

DISEASES OF TURKEYS IN THE UNITED STATES—A REVIEW

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INTRODUCTION

Researches on turkey diseases previous to the past decade were mainly concerned with blackhead (infectious enterohepatitis), which once threatened the turkey industry in America. The turkey industry has increased greatly in the past few years owing largely to the knowledge of methods of control of blackhead. As a result of this increase, many new disease problems have arisen. With the exception of infectious laryngotracheitis and infectious bronchitis, most of the common chicken diseases have been shown to affect turkeys. It is the purpose of this paper, which is a supplement to a similar review by the writer (*1*)[1] in 1933, to summarize the more recent investigations of North American workers.

BACTERIAL AND VIRUS DISEASES

Infectious sinusitis (swellhead).—This disease is characterized by nasal discharge, watery eyes, and swelling of the sinuses of the head. The swollen sinuses are usually soft to the touch and contain a turbid, viscous, mucoid exudate. In later stages it may become caseated and firm. The mortality is low, but the morbidity may be as high as 90 percent of the flock. The losses to the growers from inferior and unsalable birds are often higher than from mortality. The complete etiology is as yet unknown. The disease is transmissible to turkeys but not to chickens, according to Madsen (*2*) and work in progress at the California station.

It can be readily differentiated from fowl coryza because it cannot be transmitted to chickens. The lesions seen in the esophagus and crop of turkeys suffering from avitaminosis A serve to differentiate it from infectious sinusitis.

Tyzzer (*3*), Madsen (*2*), and Dickinson and Hinshaw (*4*) have shown that the disease may be successfully treated with silver compound, such as argyrol and silver nitrate. The last-mentioned investigators (*4*) reported good success with both 15-percent argyrol and 4-percent silver nitrate solution injected into the sinuses after removal of the exudate with a hypodermic needle and syringe.

Paratyphoid infections other than pullorum disease and fowl typhoid.—These infections are being reported with increasing frequency since Rettger, Plastridge, and Cameron (*5*) published the first report in 1933. The reports include those by Lee, Holm, and Murray (*6*) (1936), by Cherrington, Gildow, and Moore (*7*) (1937), by Hinshaw (*8*) (1937), and by Pomeroy and Fenstermacher (*9*) (1938). Edwards (*10*) has contributed more than anyone in America to the study of the species that affect turkeys. He has studied cultures from outbreaks in widely separate areas and has listed the following species in approximate order of importance: *Salmonella typhimurium, S. derby, S. senftenberg, S. newington, S. anatum, S. bareilly, S. bredeney, S. oranienburg, S. montevido, S. worthington,* and *S. minnesota.*

These diseases produce severe mortality and may kill the entire affected brood before it reaches 4 weeks of age. Severe enteritis with caseated cecal plugs seem to be the most characteristic intestinal lesions. Outbreaks in older turkeys cause less mortality than in poults. Evidence is accumulating that the diseases may be transmitted through the egg. Contaminated incubators probably contribute to the spread, and some investigators believe that external contamination of the eggshell as it passes through the cloaca of infected birds is a common source of incubator transmission.

Pullorum disease.—The first published report on this disease in the United States was made

[1] Italicized numerals in parentheses refer to Literature Cited, p. 239.

by Hewitt (*11*) in 1928. The disease has now become widespread in the United States and has been reported from several European countries, according to Brunett (*12*), Tittsler (*13*), Hinshaw (*1*), Jansen (*14*), Johnson and Anderson (*15*), Van Roekel (*16*), and Barboni (*17*). It was introduced into turkeys by the commercial hatching of poults in incubators used also for chick hatching and has now become established in turkeys in some sections.

The disease in young poults manifests itself in the same manner as in chickens, and the mortality is similar. Recent investigations at the California station have shown that the disease may be transmitted to turkey poults through eggs laid by adult carrier turkey hens in the same manner that the disease is transmitted in chickens.

The use of the tube agglutination test (1-25 dilution) has proved to be a successful means of eradicating the disease from turkey flocks, whereas the whole-blood test, as now conducted, does not appear to be efficient in detecting carriers. The inefficiency of the latter test is probably due to the fact that a large number of turkey carriers have too low antigenic titers to be detected by this test.

Swine erysipelas.—This disease, first reported in turkeys by Jarosch (*18*), was first reported in the United States (New Jersey) by Beaudette and Hudson (*19*) in 1936. Since then it has been reported from Utah by Madsen (*20*), from New York, Vermont, and Massachusetts by Van Roekel and coworkers (*21*), from California by Hoffman and Hinshaw (*22*), and from Oregon by Rosenwald.[2] In all these outbreaks, *Erysipelothrix rhusopathiae* has been shown to be the causative organism and the cultures isolated from turkeys have been identical to swine strains. In the New Jersey, Utah, and California outbreaks, there were indications that sheep may have been factors in the transmission.

The outbreaks have been sporadic in nature and have not recurred on the same premises. The fact that the disease is found in sheep (polyarthritis) in areas where turkey raising is a commercial industry may result in increased numbers of outbreaks. Van Roekel and coworkers reported that commercial anti-swine-erysipelas serum was successfully used as a therapeutic agent in one outbreak studied by them.

Fowl pox.—This malady is widespread and is caused in most instances by the same strain that affects chickens. Vaccination with chicken pox virus has proved to be an effective means of preventing the disease. Immunity does not seem to be so lasting as in chickens, and it is desirable to revaccinate all turkeys when they are placed in the breeding pens if several months have elapsed since the first vaccination.

Fowl cholera and *fowl typhoid.*—In turkeys these diseases are usually very acute, causing heavy losses in affected flocks. Both diseases are most often transmitted to turkeys by contact with infected chickens, although Skidmore (*23*) reported that fowl cholera may be transmitted to turkeys by flies.

Staphyloccal arthritis.—Jungherr (*24*) described this disease as affecting the joints of the legs of turkeys. It causes sporadic losses in birds of all ages. At times it may be mistaken for nutritional paralysis and gout.

Tuberculosis.—In turkeys, according to Hinshaw, Niemann, and Busic (*25*) it is caused by the avian type of *Mycobacterium tuberculosis.* The disease manifests itself in much the same manner as in chickens, and in all the outbreaks observed infected chickens have been responsible for transmission to the turkey flocks. In turkeys a very high incidence of bone marrow and ovarian lesions have been observed.

Ulcerative enteritis caused by Corynebacterium perdicium.—This is primarily a disease of quail but has been reported in young turkeys by Bullis and others (*26*).

PROTOZOAN DISEASES

Coccidiosis.—Tyzzer (*27*) has described two species, *Eimeria meleagridis* and *E. meleagrimitis,* as being specific for turkeys. Neither of these species affects chickens, and it is generally agreed that none of the six common chicken species affect turkeys. Under ordinary sanitary rearing methods, coccidiosis in turkeys is not an economic problem.

Disease caused by Hexamita.—Hinshaw, McNeil, and Kofoid (*28, 29*) have reported a species of *Hexamita* not previously observed in turkeys. This parasite is found throughout the intestinal tract of poults affected with an infectious enteritis and though not yet proved to be the sole etiological agent, it appears to be a factor in producing the disease. The disease affects poults from 2 to 10 weeks of age. It produces heavy mortality in young poults and marked loss in weight in older poults. The disease may be transmitted from sick poults to healthy ones, both by feeding and contact methods. All other Protozoa except *Hexamita* have been eliminated as the cause of the disease, but filtrable viruses and bacteria have not yet been entirely ruled out as associated factors. In cases that have recovered and also in mild cases, *Hexamita* have been found to be principally localized in the bursa of Fabricius and in the region of the ileocecal valve. Adult carriers appear to be the principal source of infection.

Infectious enterohepatitis (*blackhead*).—This disease is so well known and described that there is little need for details regarding it.

Recent investigations by Delaplane (*30*) and DeVolt and Davis (*31*) have verified the early work of Tyzzer (*32*) that the causative parasite is a flagellate and, like the investigations of Tyzzer and Collier (*33*) and Tyzzer (*34*), have

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[2] Personal interview.

shown that the cecum worm, though an important carrier, is not a necessary step in the life history of *Histomonas meleagridis*. DeVolt and Davis have shown that the parasite may live in the soil outside the body of the cecum worm and that it may be carried readily by flies. They also showed that the parasites may be discharged in the droppings as soon as the first day after infection and that an infected bird may spread the disease for 1 to 7 days before symptoms appear. According to Bayon (*35*), Bishop has succeeded in isolating *H. meleagridis* from liver lesions.

Possibility of immunizing turkeys against this disease is suggested in a recent paper by Tyzzer (*36*) in which he reports on the immunizing property of attenuated cultures of *H. meleagridis*. Culture strains, however, show no uniformity in regard to the degree of pathogenicity and appear to vary in their stability as immunizing agents after attenuation.

Of more scientific than practical interest are the investigations of Durant (*37*), Hunter and others (*38*), Delaplane and Stuart (*39*), and Schlotthauer, Mann, and Essex (*40*) on the relationship of the removal of the ceca to subsequent enterohepatitis exposure. They have shown that removal of the ceca will prevent the disease but that the operative mortality and cost make the method of questionable practical value.

Leucocytozoan infection.—Smith (*41*) (1895) was the first to report *Leucocytozoan smithi* in turkeys, but it was not until 1929 that Volkmar (*42*) again reported the infection in America (Minnesota and North Dakota). In 1932 Skidmore (*43*) reported another outbreak (Nebraska) and showed that the "turkey gnat" *Simulium occidentale* was a transmitting agent. Since then, Johnson and others (*44*) have described a disease causing severe losses in turkeys in Virginia, which is associated with a Leucocytozoan-like infection and which is transmitted by *S. nigroparum*.

Trichomoniasis of the upper digestive tract.—This disease, first described by Jungherr (*45*) as a mycosis, has recently been shown by Hawn (*46*) to be caused by *Trichomonas diversa*. The disease has been reported from several sections of the United States and is described in detail by Hinshaw (*8*). It usually affects partially mature turkeys on range. The characteristic symptoms are lack of appetite, drooling at the mouth, and a depressed appearance of the chest. The lesions scattered throughout the upper digestive tract are characteristic concentric rings of piled-up necrotic tissue rising in pyramid fashion to as much as 5 mm above the surface. *Trichomonas diversa* can be readily demonstrated in scrapings from the lesions.

Stabler (*47*) has shown the similarity of the *Trichomonas diversa* to *T. columbae* and believes they are the same species. He worked only with a strain of *T. columbae* since he was not able to obtain a strain of *T. diversa*.

DIETARY DISEASES

Nutritionalists are finding that in many respects the turkey differs from the chicken in its food requirements. Furthermore, the manifestations of deficiencies are not always the same, and in general the growing turkey is more sensitive to food deficiencies than is the growing chicken.

Avitaminosis A.—Hinshaw and Lloyd (*48*) and Scott (*49*) have shown that avitaminosis A develops in poults in 3 to 4 weeks if fed on a vitamin-A-free diet from the time of hatching. Symptoms are similar to those in chicks but usually more acute. Lesions in poults are confined principally to the mucous membranes of the head, the upper digestive tract, and the bursa of Fabricius. Deposits of urates in the kidneys and ureters seldom occur in turkeys. For normal growth it is estimated that twice as much vitamin A is required for turkeys as for chickens.

Dermatitis.—Lepkovsky and Jukes (*50*) have shown that lack of the flavin factor in turkey rations may produce a dermatitis in young poults. The symptoms of this deficiency disease consist of encrustations in the corners of the mouth, around the vent, and conjunctivitis. In severe cases the feet may also be involved. Fresh or dried green alfalfa meal, dried milk, and dried whey are examples of food that prevent the deficiency.

Rickets.—Scott, Hughes, and Loy (*51*) found that young turkeys developed rickets in 18 days on a diet deficient in vitamin D and that 100 percent mortality occurred in 30 days on this diet. Baird and Greene (*52*) have shown conclusively that the poult requires more vitamin D than the chick. The symptoms and pathology are similar to those in chickens.

MISCELLANEOUS DISEASES

Fungous diseases.—Two fungous diseases—aspergillosis and moniliasis of the crop—are the causes of some mortality but are not of great economic importance. The former is usually of respiratory origin involving the lungs and air sacs. It is most often associated with moldy feeds, litter, or unclean surroundings. Durant and Tucker (*53*) have recently described this disease in wild turkeys.

Moniliasis of the crop, first described in turkeys in the United States by Gierke (*54*) and later by Hinshaw (*55*), is most often caused by *Monilia albicans*. It is confined to the upper digestive tract and is similar in nature to that described in chicks by Jungherr (*56*). It has been most often observed in poults from 2 to 5 months of age and associated with some other debilitating condition or with insanitary surroundings.

Hemorrhagic enteritis.—This disease, affecting poults 7 to 12 weeks old, was recently described by Pomeroy and Fenstermacher (*57*) as causing a 10-percent mortality. The etiology of the disease was not determined.

Pendulous crop.—Hinshaw and Asmundson (*58*) describe this condition as an abnormality of the ingluvies, characterized by a temporary or permanent distention with stagnant liquid or semiliquid contents. It is seen most often in poults 9 to 12 weeks old. Asmundson and Hinshaw (*59*) present evidence that it is hereditary in nature with environment playing an important role. They concluded that the tendency to develop a pendulous crop under certain climatic conditions is determined by a recessive autosomal gene or genes.

Worm infestations.—According to Ackert and Eisenbrandt (*60*), turkeys are not so susceptible to the intestinal roundworm *Ascardia galli* as are chickens.

Most of the common tapeworms of chickens infest turkeys, causing the same types of reactions. In California *Choanotaenia infundibulum* is the most common species of tapeworm found in turkeys.

The relation of the cecum worm *Heterakis gallinae* to blackhead has already been discussed. As far as is known, this parasite does not cause any severe damage to the turkey other than as a carrier of *Histomonas meleagridis.*

Wehr (*61*), reporting on a survey on the incidence of *Capillaria sp.* in crops of turkeys, said that *C. contorta* and *C. annulata* as well as one species of *Gongylonema* were found in relative abundance in the vicinity of Washington. Neither the *Capillaria* of the upper or of the lower digestive tract of turkeys, even when fairly abundant, seem to cause much damage to the hosts.

SUMMARY

Increased interest in turkey rearing in the United States has followed the successful methods of control that have resulted from researches on blackhead (infectious enterohepatitis). With this increased interest, however, new disease problems have arisen, and the turkey has been found to be susceptible to most of the common diseases of chickens. In contrast, the nutritional requirements have been found to differ in many respects, and nutritional diseases have been the cause of considerable losses.

Diseases common to chickens and turkeys are paratyphoid infections, fowl typhoid, fowl cholera, fowl pox, tuberculosis, and fowl coryza. Exceptions are infectious laryngotracheitis and infectious bronchitis. Fowl coryza has been transmitted from chickens to turkeys, but a similar disease, infectious sinusitis (swellhead), is primarily a turkey disease. Ulcerative enteritis of quail and swine erysipelas are two recently described diseases of other animals that have caused losses in turkeys in the United States.

The turkey is somewhat resistant to intestinal roundworms (*Ascaridia galli*) but susceptible to most of the common chicken tapeworms. Turkeys appear to be immune to the six known species of chicken coccidia, whereas two species, *Eimeria meleagridis* and *E. meleagrimitis*, appear to be specific.

The etiological importance of protozoan parasites (other than *Histomonas* and the coccidia) has been receiving considerable attention by American investigators. *Trichomonas diversa* has been shown to be the cause of a necrotic ulceration of the crop of turkeys; *Leucocytozoan smithi* has been reported from several areas; and several reports have been published on the relationship of *Trichomonas, Hexamita,* amebae, and other Protozoa to enteritis.

The fungous diseases that have received attention are moniliasis and aspergillosis. Turkeys appear to be more susceptible than chickens to these diseases.

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AN OUTBREAK OF SALMONELLA ENTERITIDIS INFECTION IN BABY TURKEY POULTS

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Although the outbreak of several infectious diseases due to certain organisms of the *Salmonella* group had been reported in turkeys in other countries, no such case had been observed in our country until this sudden outbreak appeared in July 1936.

The appearance of this outbreak led us to suppose that it might be pullorum infection in baby poults, and our examination was made to isolate *S. pullorum* from the birds. However, contrary to our supposition, a paratyphoidlike organism was isolated from the liver and the heart blood and sometimes from residual yolk. The organism is a motile, Gram-negative, nonsporulating rod which does not liquefy gelatin and which grows readily in ordinary culture media. When this organism is placed in litmus milk, the latter becomes slightly acid and later alkaline. The methyl red reaction is positive, but the Voges-Proskauer reaction is negative.

In Stern's glycerin fuchsin bouillon, the growth changes to lilac color within 24 hours. It ferments glucose, dulcitol, and rhamnose within 24 hours in peptone media; glucose, arabinose, dulcitol, and rhamnose in Bitter, Weigmann and Habs' medium within 20 hours; and glucose, arabinose, dulcitol, and rhamnose in Simmon's medium within 24 hours.

From the result of cross agglutination between *S. pullorum* and this organism, O antigen is mutually demonstrated. Moreover, by testing for H antigen according to Kauffmann's classification, H antigen identical with G, O, M, Z_1, and Z_2 can be demonstrated.

The pathogenicity of this organism for turkey poults, chicks, pigeons, mice, guinea pigs, and ducklings has been definitely determined, turkey poults, mice, and guinea pigs being most susceptible to intramuscular or intraperitoneal inoculation of the organism. However, a number of the turkey poults survived the inoculation and developed into adult birds with no external symptoms.

Based on several etiological characters including the serologic property, the organism isolated from the diseased baby turkey poults has been established as being a strain of *Salmonella enteritidis*.

As the reactors to *S. pullorum* antigen had been removed from the flock by the breeder as soon as possible, a systematic investigation as to the source of the infection could not be undertaken. However, in view of the presence of the organism in residual yolk of the dead baby poults and the disappearance of extensive outbreaks of the disease after the removal of all positive reactors, the source of this infection may be considered to be the infected turkey hens which were detected by the use of O antigen to control pullorum disease on the farm and which were disposed of.

SUMMARY

In July 1936, a sudden outbreak of some highly acute disease having been observed in baby turkey poults, a number of the dead birds were sent to the laboratory for examination. Our first thought was that it might be pullorum infection, but a paratyphoidlike organism was isolated from the liver and the heart blood and sometimes from the residual yolk. The organism is a motile, Gram-negative, nonsporulating rod which does not liquefy gelatin and which grows readily in ordinary culture media. When this organism is placed in litmus milk, the latter becomes slightly acid and later alkaline. The methyl red reaction is positive, but the Voges-Proskauer reaction is negative. From the result of cross agglutination between *Salmonella pullorum* and this organism, O antigen is mutually demonstrated. Moreover, by testing for H antigen according to Kauffmann's classification, H antigen identical with G, O, M, Z_1, and Z_2 can be demonstrated. The pathogenicity of this organism for turkey poults, chicks, pigeons, mice, guinea pigs, and ducklings has been definitely determined, turkey poults, mice, and guinea pigs being found to be most susceptible.

Based on a general systematic study including several fermentation tests in special culture media, the isolated organism from the diseased baby turkey poults is established as being of the *Salmonella* group, especially a strain of *S. enteritidis*. Furthermore, the source of this infection may be considered to be the infected turkey hens which were detected by the use of O antigen to control pullorum disease on the farm.

RELATIONSHIP OF DISEASES COMMON TO GAME BIRDS AND DOMESTIC POULTRY

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INTRODUCTION

In his feeble effort to replenish the native supply of game birds by raising wild species in pens, man has encountered many obstacles in the form of disease. Corrections in the rations and in methods of incubation, brooding, and sanitation have helped to reduce the losses attributable to these sources, but various parasitic and infectious diseases are causing extensive waste, and game farming is still regarded as a hazard. It has been demonstrated that upland game birds are susceptible to many of the well-known diseases of poultry. Not all their ailments are acquired from domestic sources, however, as a number are specific for game birds. In fact, during recent years certain diseases have been observed in captive and wild game birds that apparently have not heretofore been known to science.

Experience has shown that when domestic poultry are maintained in close proximity to quail, pheasants, grouse, and partridges raised in captivity the game species become affected with many of the organisms harbored by the domestic birds. This situation becomes especially troublesome when the various forms use the same range in large numbers. Under such conditions it is conceivable that domestic poultry may acquire infections from wild birds.

Stoddard, in his monograph on the bobwhite quail (*4, p. 357*),[1] which was prepared in collaboration between the Bureaus of Biological Survey and Animal Industry of the United States Department of Agriculture, states:

> The danger of infesting bob-whites that range near human habitations with poultry diseases and parasites . . . is of importance, as these birds are known to be susceptible to several poultry diseases, and some of their worst intestinal parasites are shared with poultry.

[1] Italicized numerals in parentheses refer to Literature Cited, p. 243.

SPECIFIC DISEASES

Blackhead, or enterohepatitis, one of the most feared diseases of domestic turkeys, is found to be equally destructive to wild turkeys when they are restricted to pen conditions on game farms. It is also a serious plague among pen-raised bobwhite quail and ruffed grouse (*3, p. 17*) when they are maintained in close confinement. As a rule, blackhead does not assume the proportions of enzootic infection in quail if the birds are maintained under good hygienic conditions. Under the physical demand of high egg production, however, many quail hens die from the disease. The causative organisms may be harbored on game farms where only quail or grouse are kept, but the presence of domestic poultry, especially turkeys, on the premises regularly increases the incidence of this disease.

Coccidiosis (*2, p. 166*), a well-known plague of young chickens, is equally destructive to young game birds. In general, the organisms of this group are host specific and are rarely cross transmitted. Most of the severe losses in quail are believed to be due to species of coccidia peculiar to this group of birds. It may be noted, however, that two species parasitic in chickens have been found in the California quail also.

Knowledge of the occurrence of trichomoniasis is somewhat meager, but serious losses in quail and wild turkeys raised on game farms are attributable to this disease. The organism found in these outbreaks appears to be identical with those observed in similar enzootics in domestic-poultry plants, although preliminary studies in the laboratory indicate that they require slightly different media for artificial cultivation. The symptoms and the rate and percentage of losses likewise parallel those observed in domestic birds. The likelihood of interchange of the infection from one group of birds to another is recognized, and poultry pathologists having extensive experience with this disease recommend the practice of isolation and quarantine of affected birds that may serve as carriers.

The common gapeworm (*Syngamus trachea*) of domestic chickens, also parasitic in pheasants and quail (*1, pp. 34–38*), is spread by the domestic turkey and wild birds of flight. Game breeders have learned that land which has been ranged over by turkeys constitutes a dangerous site for game-bird pens until the contaminating worm eggs left there in the turkey droppings become noninfectious.

Similarly, the cecal worm *Heterakis gallinae* (*1, p. 52*), so common in farm flocks of chickens, is parasitic in pheasants, quail, and wild turkeys. Therefore, game breeders who have had experience with the parasite have learned to reduce their risks by avoiding the use by game stock of the poultry pens or runs.

Many other parasites not so commonly encountered, although capable of producing serious injury and death, are transmissible from domestic chickens to quail, pheasants, and wild turkeys. Among the parasites listed by zoologists (*4, pp. 256–305*) as being parasitic in various groups of birds may be mentioned: *Capillaria contorta*, parasitic in domestic ducks and turkeys; *Tetrameres americana*, parasitic in quail and chickens; *Gongylonema ingluvicola*, parasitic in quail, chickens, and turkeys; *Seurocyrnea colini*, parasitic in quail and turkeys; *Ascaridia lineata*, parasitic in quail and chickens; *Capillaria retusa*, parasitic in quail, turkeys, and guinea fowl; *Subulura strongylina*, parasitic in quail, chickens, and guinea fowl; *Hymenolepis carioca*, parasitic in quail, chickens, and turkeys; and *Raillietina cesticillus*, parasitic in quail, chickens, turkeys, guinea fowl, and pheasants. These parasites, depending on the species, attack different parts of the alimentary tract and cause varying degrees of injury to the delicate structures.

One of the best known of the diseases of chickens, pullorum disease, has been observed to become established in pheasant flocks (*3, p. 6*). Game farmers in the British Isles as well as in North America have reported severe losses from this infection. Pheasant chicks hatched in incubators or raised in brooders where diseased chicks have been maintained are the most frequent victims. There is insufficient information to show whether this condition will become established in pheasants in endemic form and carry over through succeeding generations in flocks of these birds alone.

One of the most striking examples of disease transmission from domestic chickens to game birds is that of tuberculosis (*3, p. 8*). It is a common practice on many game farms to use domestic hens for incubating pheasant eggs and for hovering the young. Numerous instances are on record of pheasants raised in this manner being infected with avian tuberculosis. Pheasants seem to be peculiarly susceptible. On autopsy it is not uncommon to find the liver, spleen, and intestine involved and even the body muscles and bones.

Chicken pox is described as being also a disease of serious consequences on quail farms. Stoddard (*4, p. 327*) describes an experimental test as well as a practical demonstration of the spread of the virus of this disease from chickens to quail.

CONCLUSIONS

The rapidity of spread of infections on game farms appears to equal if not surpass the most spectacular outbreaks observed on poultry farms. Many instances have been observed in which the production of a season is almost entirely wiped out in a few weeks through losses by disease. Respiratory involvements, conditions simulating roup in chickens, protozoan diseases, infestation by the larger parasites, as well as various intestinal infections, are feared by the experienced game breeder.

When disease does make its appearance on a game farm, the nature of the stock and the usual style of construction render it difficult to cope with the trouble. Game birds are hard to tame, and special types of pens and coops are required to prevent injury and yet afford sanitation. It may be pointed out that wild birds are not so resistant to many of the maladies resulting from pollution as are domestic stock. Birds that have been recently penned and raised under controlled conditions have not developed that tolerance to polluted environment so characteristic of domestic stock. When one observes the unhealthful surroundings under which flocks on some poultry farms survive, it becomes apparent that considerable racial resistance exists in these birds. Nor is it surprising that quail, pheasants, and grouse, accustomed for countless centuries to nesting and raising their broods in an environment free from heavy contamination and pollution, should be unable to cope with the effects of contamination and the products of insanitation.

From time to time the suggestion has been made by poultry pathologists that wild birds may be regarded as carriers of disease and parasites among poultry flocks, and these probabilities cannot be disregarded. The fact remains, however, that game farms cannot flourish by using the old method of incubating the eggs and brooding the young birds under hens collected on the single standard of broodiness from a miscellany of farm-raised flocks. Large sums have been spent in attempts to accomplish this. Those not familiar with the dangers of disease have wasted great numbers of eggs by attempting to raise game birds by substituting for the natural wild-game hen the docile domestic hen. Modern game farms regularly use artificial incubating and brooding systems that are as carefully organized as the up-to-date poultry plants.

A few basic principles are coming to be the guide of modern game farmers, and these are proving effective in reducing losses from disease. Most important are the maintenance of stock, especially the young chicks, on strictly sanitary floors and the exclusion of any form of domestic poultry from the premises.

SUMMARY

Difficulties in the attempts at artificial propagation of game species have brought to the attention of the would-be propagator a realization of the relationship of the parasites and diseases of these game species and those of domestic poultry.

In addition to the known diseases of domestic poultry that may be shared in common with game birds, diseases new to science have been found, some of which appear to be specific for certain species of game birds. Raising domestic poultry and game birds in close proximity frequently results in heavy losses of the game species as a result of their becoming affected with organisms harbored by the former.

Among the diseases of domestic fowls that are also infectious to game birds raised in captivity may be listed enterohepatitis, coccidiosis, pullorum disease, tuberculosis, chicken pox, and a long list of parasites, including the gape worm, the common ascarid, and the *Raillietina* species of tapeworm.

Game species do not possess the racial resistance to pollutions apparently inherent in domestic stock.

One of the basic principles in the guidance of game farmers is the maintenance of stock on sanitary floors and grounds away from all forms of domestic poultry.

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GEFLÜGELCHOLERA UND TUBERKULINPROBE

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Die Anwendung der von van Es und Schalk zuerst vorgeschlagenen intradermalen Tuberkulinprobe hat sich zur Erkennung der latenten Tuberkulose der Hühner glänzend bewährt. Doch sind bei ihrer Beurteilung diagnostische Irrtümer möglich, die geeignet sind, sie u. U. in Misskredit zu bringen. Die Möglichkeit der Verwechslung der positiven Tuberkulinreaktion mit der sog. Läppchenkrankheit habe ich in meinem Vortrag am VI. Weltgeflügelkongress in Leipzig 1936 bereits gestreift (Kongressbericht Bd. II, S. 141), hier sei nun, unter Zugrundelegung der Forschungsergebnisse meiner Mitarbeiter (Csontos, Hirschenstein, Révész, Mihály, Limbek, Kárnik und Bamberger), auf die diesbezüglichen Verhältnisse näher eingegangen.

Spritzt man konzentriertes Geflügeltuberkulin Hühnern in die Haut des einen Kehllappens ein, so entsteht sowohl bei gesunden wie bei tuberkuloseinfizierten Tieren alsbald eine ödematöse

Anschwellung, die nach 0.5–4 (im Mittel 1.5) Stunden ihren Höhepunkt erreicht und nach 6–18 Stunden anfängt abzuflauen, um nach etwa 36 Stunden fast ganz zu verschwinden. Diese erste Phase der Tuberkulinwirkung ist bedingt durch nicht spezifische Stoffe des Tuberkulins, namentlich durch die Extraktivstoffe der zur Züchtung der Tuberkelbazillen verwendeten Bouillon im Verein mit seinem hohen Gehalt an Glyzerin. Dass dem so ist, lässt sich durch die Einspritzung von eingeengter reiner Glyzerinbouillon zeigen. Das Entstehen des Ödems ist in der Hauptsache die Folge einer vorübergehenden Auswanderung von Flüssigkeit aus den Blutgefässen in die Subkutis und die tieferen Schichten der Lederhaut mit Ansammlung lediglich von pseudoeosinophilen Zellen. Es handelt sich somit bloss um eine Reaktion, die den Ausgleich einer osmotischen Störung im Kehlläppchengewebe bezweckt. Dass daher die Tuberkulinreaktion während dieser nicht spezifischen Phase nicht beurteilt werden darf, liegt auf der Hand. Der Grad der Verdikkung des Kehlläppchengewebes während der nicht spezifischen Phase hängt selbstverständlich davon ab, in einer wie hohen Konzentration das Tuberkulin Extraktivstoffe und Glyzerin enthält. Sogenannte gereinigte Tuberkuline, etwa durch Fällung mit Alkohol bereitete Erzeugnisse, verursachen nur eine ganz geringfügige Anschwellung. Die Anschwellung während der nicht spezifischen Phase ist deutlich ödematös, sie fühlt sich teigig an. Sie beschränkt sich stets auf die unmittelbare Umgebung der Einstichstelle.

Während bei nicht infizierten Hühnern mit dem Abklingen der nicht spezifischen Phase die Tuberkulinwirkung beendigt ist, schwillt bei tuberkulösen Hühnern das beimpfte Kehlläppchen alsbald erneut an, diesmal zufolge einer Entzündung, die durch die spezifischen Stoffe des Tuberkulins bedingt wird. Der Vorgang lässt sich sehr hübsch an histologischen Schnitten verfolgen. Es erscheinen nämlich, zunächst in der Umgebung von erweiterten Venen, in der Subkutis und in den tieferen Schichten der Lederhaut nicht granulierte entzündliche Zellelemente, hauptsächlich Histiozyten und Makrozyten. Die ersten derartigen Zellelemente können schon nach 4 Stunden auftauchen, später häufen sie sich in einer derartigen Menge an, dass sie auch dann noch eine beträchtliche Dickenzunahme des Kehlläppchens bedingen, wenn das Ödem der nicht spezifischen Phase bereits verschwunden ist. Diese die spezifische Phase der Tuberkulinwirkung repräsentierende Entzündung erreicht meist wohl erst in der 48. Stunde ihren Höhepunkt und kann auch noch nach 72 Stunden sehr ausgeprägt sein, sie nimmt aber oft schon nach 36 Stunden ab. Es ist daher am richtigsten, das Ergebnis der positiven Tuberkulinreaktion schon um die 36. Stunde abzulesen.

Dem histologischen Bilde entspricht auch das Ergebnis der klinischen Untersuchung. Die spezifische Anschwellung des beimpften Läppchens fängt manchmal schon frühzeitig an, sodass die nicht spezifische Anschwellung fast unmerklich in die spezifische übergeht, in anderen Fällen dagegen beginnt die spezifische Anschwellung erst nach dem merklichen Abflauen der nicht spezifischen, sodass sich dann zwei entschiedene Maxima feststellen lassen. (Die Verhältnisse sind schematisch in der nebenstehenden Zeichnung dargestellt.) Wichtig ist daher, dass sich die spezifische Anschwellung, ebenso wie die nicht spezifische, auf die unmittelbare Umgebung der Einspritzstelle beschränkt, sie fühlt sich jedoch nicht ödematös, sondern derb an, denn sie ist ja, falls sie nicht vor der 36. Stunde untersucht wird, allein durch die Anhäufung von soliden Gebilden, von entzündlichen Zellelementen, bedingt.

Mit der Tuberkulinreaktion wird häufig verwechselt jene Entzündung der Kehlläppchen, die vielfach "Kehlläppchenkrankheit" (Wattle disease, Edema of the wattles) bezeichnet wird. Bekanntlich handelt es sich hierbei in den meisten Fällen um eine gutartige Form der Geflügelcholera, die dadurch entsteht, dass bei Hühnern,

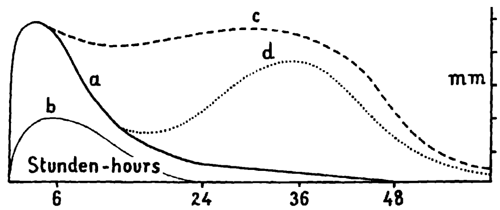

ABBILDUNG 1.—a = Nicht spezifische Anschwellung des Kehlläppchens nach Einspritzung von gewöhnlichem Tuberkulin; b = Nicht spezifische Anschwellung des Kehlläppchens nach Einspritzung von gereinigtem Tuberkulin; c = Spezifische Anschwellung des Kehlläppchens nach Einspritzung von gewöhnlichem Tuberkulin (Läppchenverdickung mit einem Maximum); d = Spezifische Anschwellung des Kehlläppchens nach Einspritzung von gewöhnlichem Tuberkulin (Läppchenverdickung mit zwei Maxima).

die mit Geflügelcholerabazillen latent infiziert sind (Bazillenträger), in den Kehlläppchen durch den Blutstrom dahin gebrachte Geflügelcholerabazillen sich ansiedeln und eine Entzündung verursachen, falls deren Gewebe auf irgendeine Weise für die Ansteckung anfällig geworden ist. Ein Anfälligwerden des Kehlläppchengewebes kann durch beliebige traumatische Einflüsse bewirkt werden. Ich glaube nicht fehlzugehen, wenn ich behaupte, dass das besonders häufige Auftreten dieser Krankheitsform gerade bei Hähnen damit zusammenhängt, dass diese Tiere an ihren Kopfanhängen sich häufig Verletzungen zuziehen, indem sie einander bekämpfen. Uns interessiert in diesem Zusammenhang hier die Erfahrung, dass u.U. auch die Einspritzung von Tuberkulin in die Haut und das damit verbundene Entstehen eines Ödems in der Subkutis und in der Lederhaut eine besondere Disposition (Locus minoris resistentiae) schaffen können für die Entwicklung einer "Läppchenkrankheit" bei Tieren, die zufälligerweise Träger von Geflügelcholerabazillen sind. Darüber, dass Geflügelcholerabazillenträger keine Seltenheit sind, habe ich bereits in meinem Vortrag am VI. Weltgeflügelkongress in Leipzig berichtet.

Die Tatsache nun, dass bei tuberkulingeimpften Hühnern infolge der Gewebeschädigung durch die Tuberkulineinspritzung eine "Läppchenkrankheit" entstehen kann, birgt in sich eine nahmhafte Fehlerquelle bei der Beurteilung der Tuberkulinreaktion. Vieles spricht dafür, dass so manches abfällige Urteil hinsichtlich der Leistungsfähigkeit der intradermalen Tuberkulinprobe die Verwechslung der "Läppchenkrankheit" mit der positiven Tuberkulinreaktion zu Grunde hatte. Tatsächlich hat die "Läppchenkrankheit" einige "Ähnlichkeit mit der positiven Tuberkulinreaktion, sie lässt sich jedoch von ihr unschwer unterscheiden.

Entsteht bei einem mit Tuberkulin behandelten Tiere eine "Läppchenkrankheit," so entwickelt sich selbstverständlich auch hier zunächst eine nicht spezifische Anschwellung des Kehllappens, die sich auf die Umgebung der Einstichstelle beschränkt. Während aber bei nicht tuberkulösen Tieren diese Anschwellung, wie bereits bemerkt, sonst spätestens binnen 36 Stunden abflaut, nimmt sie bei Tieren, bei denen eine "Läppchenkrankheit" entsteht, im Gegenteil stetig zu. Dieses Bestehenbleiben bzw. das Fortschreiten des Ödems wird durch eine von den Geflügelcholerabazillen hervorgerufenen Entzündung bedingt. Diese Entzündung unterscheidet sich aber wesentlich von der Entzündung, die während der spezifischen Phase der positiven Tuberkulinreaktion entsteht. Es handelt sich nämlich nicht nur um eine Ansammlung von entzündlichen Zellelementen, sondern auch um den Austritt von Blutflüssigkeit hauptsächlich in die unteren Schichten der Lederhaut und in die Subkutis. Dabei übertrifft die Menge der ausgetretenen Flüssigkeit sehr wesentlich jene beim Ödem der unspezifischen Phase der Tuberkulinwirkung, sodass die Bindegewebsfasern allenthalben auseinander gedrängt werden. Es entstehen dadurch grosse Hohlräume, in denen die Flüssigkeit teils in nicht geronnenem, teils in geronnenem Zustande sich befindet.

Makroskopisch äussert sich diese Entzündung in einem hochgradigen Ödem, das sich dabei nicht nur auf die Umgebung der Impfstelle beschränkt, sondern den ganzen Kehllappen erfasst, sehr oft sogar auch auf die Kehlganggegend und den anderen Kehllappen übergreift. Das ödematös gewordene Kehlläppchen erscheint glasig durchscheinend und fühlt sich teigig an. Schon diese Eigenschaft der Anschwellung unterscheidet die "Läppchenkrankheit" aufs Entschiedenste von der positiven Tuberkulinreaktion. Dabei ist aber als weiteres Unterscheidungsmerkmal noch anzuführen, dass die derbe Anschwellung der positiven Tuberkulinreaktion nach 48 Stunden bereits abnimmt und nach weiteren 1–2 Tagen vollauf verschwindet, während die ödematöse Anschwellung bei der "Läppchenkrankheit" zumindest bis zum 3. Tage stetig zunimmt und erst nach weiteren einigen Tagen allmählich verschwindet oder ein Absterben und dann entweder eine bindegewebige Abkapselung oder das Abstossen der erkrankten Gewebe nach sich zieht. Achtet man hierauf, so wird man das Auftreten einer "Läppchenkrankheit" nicht für eine positive Tuberkulinreaktion halten und dann eventuell bei der Zerlegung das Freisein des Tieres von jeglicher tuberkulöser Infektion feststellen müssen.

Einer einzigen Schwierigkeit hat man noch zu begegnen. Bei tuberkulösen Tieren nämlich, bei denen im Anschluss an eine Tuberkulineinspritzung eine "Läppchenkrankheit" sich entwickelt hat, wird durch die ödematöse Anschwellung des Läppchengewebes die etwa entstandene positive Tuberkulinreaktion verdeckt. Man wird daher beim Auftreten der "Läppchendrankheit" von einem Urteil über den Ausfall der Tuberkulinreaktion Abstand nehmen und die Diagnose hinsichtlich des Vorliegens von Tuberkulose oder des Freiseins von einer tuberkulösen Infektion von einer nachträglich am anderen Kehlläppchen noch einmal ausgeführten Tuberkulinprobe abhängig machen müssen. Nach unseren Erfahrungen pflegt nämlich ein zweites Mal bei demselben Tiere die "Läppchenkrankheit" nicht mehr zu entstehen.

Nach unseren Erfahrungen scheint übrigens zur Entwicklung der "Läppchenkrankheit" die Schaffung eines Locus minoris resistentiae im Kehlläppchen nicht zu genügen, denn wir haben in vielen Beständen, wo Geflügelcholerabazillenträger sicherlich zugegen waren, anlässlich öfters wiederholter Tuberkulinimpfungen nur gelegentlich das Entstehen dieser Krankheitsform beobachtet. Es dürfte daher hierzu auch eine weitere, wenngleich an sich nur geringe, Schwächung des ganzen Organismus notwendig sein. Ein Faktor, der eine derartige Beeinflussung des Tierkörpers zu veranlassen vermag, liegt jedenfalls in der jahreszeitlich bedingten Witterung. In unseren Versuchen haben wir nämlich das Auftreten der "Läppchenkrankheit" nach Tuberkulinimpfungen bisher ausnahmslos in der Herbst- und Winterzeit, in den Monaten Oktober bis Februar, beobachtet. Ob und wieweit hier auch andere Faktoren mit im Spiele sind, muss erst die Zukunft lehren.

ZUSAMMENFASSUNG

Die intradermale Tuberkulinprobe nach *van Es* und *Schalk* ist ein hervorragendes Verfahren zum Nachweis einer tuberkulösen Infektion der Hühner. Die positive Reaktion äussert sich in einer festen Anschwellung des beimpften Kehlläppchens nur in der Umgebung der Einstichstelle, die durch die Anhäufung von entzündlichen Zellelementen hervorgerufen wird. Sie sollte nicht vor der 36. Stunde beurteilt werden, da vor diesem Zeitpunkt eine nicht spezifische, lediglich ödematöse Anschwellung des Kehlläppchens vorhanden sein kann, die durch den Gehalt des Tuberkulins

an nicht spezifischen Extraktivstoffen und an Glyzerin bedingt wird, binnen 36 Stunden jedoch abflaut.

Bei Hühnern, die als Bazillenträger in ihrem Körper Geflügelcholerabazillen beherbergen, kann durch die Einspritzung von Tuberkulin im Gewebe des Kehlläppchens eine Disposition für das Entstehen der "Läppchenkrankheit" geschaffen werden. Die "Läppchenkrankheit" kann mit dem positiven Ausfall der Tuberkulinprobe verwechselt werden, da auch sie mit einer Verdickung des beimpften Läppchens einhergeht. Die Anschwellung des Läppchens zufolge der "Läppchenkrankheit" beschränkt sich jedoch nicht auf die unmittelbare Umgebung der Einstichstelle, sondern umfasst das ganze Läppchen und greift häufig auch auf das andere Läppchen über, ferner ist sie nicht festen, sondern hochödematösen Charakters und verschwindet weniger rasch als die positive Tuberkulinreaktion. Das Entstehen der "Läppchenkrankheit" im Anschluss an Tuberkulineinspritzungen scheint jahreszeitlichen Schwankungen zu unterliegen. Die Mitarbeiter des Referenten haben sie nur in den Monaten Oktober bis Februar beobachtet.

SUMMARY

The intradermic tuberculin test according to van Es and Schalk is an outstanding method for detecting a tuberculous infection in chickens. The positive reaction manifests itself in a firm swelling of the injected wattle in the vicinity of the point of puncture, which is caused by the accumulation of inflammatory cell elements. This reaction should not be judged before the thirty-sixth hour, as before this time there may be a nonspecific, merely edematous, swelling of the wattle, caused by nonspecific extractive matters of glycerin contained in the tuberculin, but which abates within 36 hours.

In chickens which, as bacillus carriers, are harboring fowl cholera bacilli in their bodies, a tendency to set up the so-called wattle disease may be created by injection of tuberculin into the tissue of the wattle. The wattle disease may be confused with the positive tuberculin reaction, as the latter is also accompanied by a swelling of the injected wattle. The swelling of the wattle caused by the wattle disease is not confined, however, to the immediate vicinity of the point of puncture but involves the whole wattle and frequently also attacks the other wattle; furthermore, it is not of a firm but of a highly edematous character and disappears less rapidly than the positive tuberculin reaction. The occurrence of the wattle disease after tuberculin injections seems to be subject to seasonal variations. The collaborators of the author observed it only from October to February.

USE OF THE CHICKEN EMBRYO IN POULTRY-DISEASE STUDIES[1]

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The developing avian egg has long served as a fruitful subject for biological and embryological study. As early as 1749 Beguelin, according to Gerlach (cited by Goodpasture, 1938) made a window in the eggshell in order to observe the embryo during its development. Peebles (1898) devised a method for experimentation on the embryo by providing a window in the shell, and the method later was adapted by Rous and Murphy to problems in pathology.

Levaditi (1906) described work done by Bordet and himself with a specific spirillosis of fowls by introduction of infective blood into the egg. Infection was transmitted to the embryo by injection into the albumen both before and after 3 to 4 days of incubation. Rous and Murphy (1911), and Murphy and Rous (1912), employed developing chicken, duck, and pigeon eggs for propagation of certain virus agents. They produced tumors of the embryo and extra-embryonic membranes by injecting filtrates and suspensions of the Rous chicken sarcoma. Murphy (1912, 1913) cultivated the Jensen rat sarcoma and other tumors on the chorio-allantoic membranes. Rous and Murphy utilized the method of Peebles (1898) for manipulation of the egg. Subsequently, the avian egg was largely used for tissue grafts, but Juan and Staub (1920) carried fowl pest virus through six successive passages on developing eggs by inoculation of the yolk. Gay and Thompson (1929) found that vaccine virus inoculated into the yolk sac of incubating eggs could be recovered from the second but not from the third transfer. It remained, however, for Goodpasture and coworkers to reveal the potentialities of the developing egg in the approach

[1] In view of recent progress resulting from cultivation of various viruses on the developing avian egg, this paper reviews chiefly the work on this phase as it is concerned with avian pathology. Methods employed and the results obtained with other infectious agents as well as certain factors, e. g., physical, chemical, etc., in the utilization of the avian embryo are dealt with, although in a limited way because of the necessary brevity of this review.

of various virus problems, and thus to stimulate much of the recent work in this direction.

FURTHER APPLICATION OF EGG CULTIVATION OF AVIAN VIRUSES

In 1931 Woodruff and Goodpasture reported the cultivation of fowl pox virus through successive transfers on the extra-embryonic membranes of chicken embryos. Their technique was based on the method of Clark (1920) for embryological study. Later Goodpasture, Woodruff, and Buddingh (1931, 1932) recorded the cultivation of vaccinia and herpes simplex in developing eggs. Since then a great many viruses as well as certain bacteria, fungi, rickettsia, etc., have been propagated and studied by means of the chicken embryo and its membranes. Recently in our laboratory, as reported by Levine, Brandly, and Graham (1939), pathogenic protozoa (*Tritrichomonas foetus*) from cattle have been cultivated serially in pure culture in the allantoic sac of developing eggs.

Rivers and Schwentker (1932) passed the virus of Pacheco's parrot disease through six generations of developing eggs without altering the infectivity for experimental birds. Inoculation of the extra-embryonic membranes was accomplished through an opening of the shell over the air sac. Burnet (1933) carried Kikuth's canary virus through several series of developing eggs. His technique was a variation of that of Woodruff and Goodpasture (1931), in which an artificial air sac is produced on the side of the egg in order to facilitate uniform inoculation of a large free surface of the chorio-allantoic membrane. More recent reports on the egg cultivation of other viruses affecting poultry and birds include those of infectious laryngotracheitis by Burnet (1934) and Brandly (1935), fowl plague and Newcastle disease by Burnet and Ferry (1934), psittacosis by Fortner and Pfaffenberg (1935) and Burnet and Rountree (1935), and avian virus bronchitis by Beaudette and Hudson (1937). Jarmai (1934) reported that developing chicken embryos could be infected after the tenth day with the agent of leukemia. This observation has been confirmed in a limited way in our laboratory. In the report of the Chief of the Bureau of Animal Industry (1938) the results of inoculating chick embryos with leukotic tissue suspensions are given. Of 116 inoculated embryos, 45 percent hatched; whereas of 106 uninoculated embryos, 76.4 percent hatched. One chick inoculated as a 6-day embryo died at 22 days of age of generalized leukosis of the tumor type. Burnet (1936) stated that he had also cultivated pigeon pox and sparrow pox viruses in the chicken egg. In this laboratory three pigeon strains of pox virus as well as the "antidiphtherin" of de Blieck have been propagated in chicken eggs during the last 3 years. Beaudette and Hudson (1938) reported continued serial passage of pigeon pox virus on the chorio-allantois of chicken and duck eggs.

Natural infection of ring-necked pheasants, as reported by Tyzzer and coworkers (1938), and of pigeons, as reported by Fothergill and Dingle (1938), with the virus of equine encephalomyelitis directs attention to the fact that this virus was propagated as early as 1935 by Higbie and Howitt. The virus of rabies, although rarely recognized as affecting birds in nature, has been reported to be cultivable in developing chicken eggs by Peragallo (1937) and by Kligler and Bernkopf (1938).

PATHOLOGY

The differentiation of certain virus diseases of fowls—fowl plague and Newcastle disease reported by Burnet and Ferry (1934), canary and fowl pox reported by Burnet (1933), and fowl and pigeon pox reported by Brandly and Dunlap (1937)—may be accomplished on the basis of gross and microscopic pathology produced in the chorio-allantois. Burnet (1936) observed gross differences in chorionic lesions among strains of laryngotracheitis viruses, and similar variations were seen by Brandly (1936). The latter's finding that laryngotracheitis virus may induce gross lesions in chicken and turkey membranes but not in those of the duck, guinea fowl, and pigeon suggests the differential value of this feature.

DETECTION AND TITRATION OF VIRUSES

The superiority of the developing egg to the baby chick for accurate titration as well as for detection of minute quantities of viruses naturally attacking birds has been demonstrated. Satisfactory titrations have been accomplished with viruses rapidly lethal for the embryo, e.g., the viruses of fowl plague and Newcastle disease, as reported by Burnet and Ferry (1934), and of equine encephalomyelitis, reported by Higbie and Howitt (1935); and also with others which produce plaques or pocklike foci on the chorio-allantois, e.g., avian pox viruses, reported by Burnet (1936) and Burnet and Lush (1936), and infectious laryngotracheitis, reported by Burnet (1936). The suitability of the egg for determining virus neutralization was demonstrated with equine encephalomyelitis by Higbie and Howitt (1935) and as a means of serological differentiation between fowl and canary pox by Burnet and Lush (1936). The embryo may allow comparative studies on a mutually susceptible host not otherwise available, according to Burnet and Lush (1936) and Goodpasture (1938). In work with laryngotracheitis, Burnet (1936) found the chorio-allantoic membrane to be a satisfactory medium for elucidation of the mechanism of the virus-serum reaction. By use of the egg Burnet (1936a) was able to clarify the epizoology of laryngotracheitis in Australia.

TISSUE-CULTURE MEDIA

The chick embryo has been used extensively as a source and constituent of tissue-culture media for the propagation of a number of virus agents of mammals as well as poultry. Reports on cultivation of avian viruses on various media, particularly of the type of Carrel and Rivers (1927) and Li and Rivers (1930), include those with fowl plague, reported by Hallauer (1931) and Plotz (1932); fowl and pigeon pox virus, by Findlay (1928), Glover (1929-30), and Brandly and Dunlap (1937); Newcastle disease by Topacio (1934); leukemia by Furth and Stubbs (1934) and Verne and coworkers (1936); psittacosis, by Bland and Canti (1935); and infectious laryngotracheitis by Beach (1932). Cox (1935) reported that chick-embryo tissue cultures was a more sensitive method than animal inoculation for detecting equine encephalomyelitis virus.

THE INFECTIVE PROCESS

The observations by Furst (1935) on the pathogenesis and comparative pathology of bacterial infection of the embryo and of the postnatal chick, as exemplified by egg-borne *Salmonella pullorum* infection, suggest the suitability of the embryo and its membranes for studying problems of bacterial as well as fungous and other infections. Goodpasture (1933) pointed out the possibilities inherent in the avian embryo and its membranes for the study of microbial virulence, invasion, and host reaction. He also called attention to the opportunity for study of noninfectious injuries of various sorts, such as vascular and cellular response and the foreign-body reaction. Later, Goodpasture and Anderson (1937) reported their findings on the use of the developing egg for observation of phenomena of infection as revealed with different bacteria, including staphylococci, streptococci, and avian tubercle bacilli. Brandly and Graham (1936) found that differences in pathogenicity and virulence among strains of certain bacteria may be determined by means of inoculation of developing chicken eggs. More uniform and accurate measurements of the virulence of several species of *Salmonella* affecting fowl and of *Pasteurella avicida* were obtained by the use of incubating eggs than of experimental animals. Additional work carried on by Brandly and Graham[2] in the titration of *Salmonella pullorum* revealed a remarkable uniformity in susceptibility even among fertile eggs representing different genetic background (pullorum susceptible and resistant) and varying periods of development (8-18 days).

SENSITIVITY OF THE EMBRYO

The sensitivity of the embryo as shown toward viruses and other infectious agents has been demonstrated also in the case of certain volatile agents, as shown by Schmid (1930). It has been utilized to demonstrate the toxicity of mercury compounds, as reported by Deakin and Robertson (1933), and of certain serums, as shown by Baumann and Witebsky (1934); also to determine the effect of snake venom, by Witebsky and others (1935), and of various drugs and cold for the developing embryo in vitro, by Neter and Witebsky (1935). The effect of diphtheria toxin on the chick embryo in vivo was demonstrated by Goodpasture and Anderson (1937), and titrations of this toxin were made on the egg by Evans (1938). Elucidation of selenium poisoning in poultry and other livestock was accomplished by injection of this element into the egg by Franke and coworkers (1936). The effect of the introduction of manganese into the albumen of eggs in the prevention of perosis in potentially susceptible embryos was shown by Lyons and Insko (1937).

PURE-CULTURE VIRUSES FOR IMMUNIZATION

Because of their many obvious advantages pure culture, egg-propagated, and tissue-cultured viruses have aroused much interest from the standpoint of immunization in poultry as well as in man and other mammals. Brandly (1935, 1936) obtained satisfactory results in laryngotracheitis and fowl pox immunization of chickens with the respective egg-grown viruses. It was concluded that the egg-cultivated viruses could be substituted to advantage for those produced in the chicken. Beaudette and Hudson (1937a) reported the use of egg-propagated laryngotracheitis virus in vaccination. In experimental immunization studies with egg-propagated and tissue-cultured as well as skin-lesion fowl and pigeon pox viruses, Brandly and Dunlap (1937) found the egg virus invariably higher in concentration than that from the other sources. It could be propagated more easily and economically than that produced by tissue-culture methods. Furthermore, egg-cultivated viruses reduce the potential hazards of bacterial or other virus contamination inherent in the use of skin-lesion virus.

In this connection attention was given to the possibility that continued egg propagation might effect desirable modification which might render these pox viruses more suitable for use in immunization. However, significant alterations in the virulence or immunizing properties of these agents were not observed as a result of numerous egg passages (68 egg passages with a fowl pox strain, 15 passages with a pigeon strain). The egg-propagated fowl pox virus was satisfactory also for immunization of turkeys against pox, as shown by the Illinois station (1935-36) and Brandly and Dunlap (1938). Beaudette and Hudson (1938) reported satisfactory results from the use of egg-propagated pigeon virus in field vaccination of chickens against pox. Buddingh (1938) found no alterations in fowl pox virus as a result of continued propagation upon the chorio-allantois of chicken eggs, but one intracerebral passage of the virus in baby chicks was sufficient to produce marked changes in its behavior toward the chick-embryo membranes and the skin of baby chicks.

[2] Unpublished data.

DISCUSSION

The recent extensive use of the living-chick embryo and its membranes for experimentation and investigation of various disease problems of chickens as well as other species has yielded much valuable information. That the potentialities of the method are far from exhausted is, nevertheless, obvious. Certain limitations and possible pitfalls must be recognized, however, in the application of the incubating egg to the study of pathology and related problems. Although the phenomena of invasion and infection may largely parallel those in the growing and mature birds, certain anatomic and physiological differences may impose definite limitations on comparative study. In this connection Murphy and Rous (1912) early observed that the growth of chicken sarcoma in the extra-embryonic membranes is seldom invasive, metastasis never occurring via the blood stream in spite of predilection of the tumor for this path of distribution in adult hosts. The mesodermal affinity of this virus was acknowledged in the manner in which the inoculum was introduced into the egg. The nature and extent of the infective process with other agents will also depend on whether or not inoculation is made upon or within the allantoic sac or into the amniotic cavity or the yolk sac. Failure to recognize that nonspecific injury (ulcers, pseudo-foci, etc.) and embryonic mortality may be indistinguishable from that induced by specific factors may lead to confusion and error.

SUMMARY

The work cited herewith emphasizes particularly the uses and value of the avian embryo in the study of pathogenesis, pathology, and immunity. It includes (1) propagation and study of the viruses in pure culture; (2) detection, even in minute quantities as well as titration, of infectious and toxic agents and antiserums; (3) pathologic and serologic study and differentiation of various infectious agents and their products; (4) elucidation of the role of certain nutritional and physiological factors in disease causation; (5) utilization of egg-cultivated and tissue-culture viruses in experimental and field immunization; (6) investigations of fundamentals of resistance and immunity; and (7) ready availability and economy of the developing egg as compared with the postnatal chick or usual laboratory animal. In addition, substitution of the incubating egg for the chicken or other experimental animal eliminates the expense of quarters, equipment, and feed and, above all, the hazards of cross and inapparent infection. Furthermore, by working with eggs instead of animals, the dangers of dissemination of infection from the laboratory are greatly minimized.

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NEWCASTLE DISEASE

By N. DOBSON, *Senior Research Officer, Veterinary Laboratory, Ministry of Agriculture and Fisheries, Weybridge, England*

The incidence of Newcastle disease in great Britain has been relatively small. Following the diagnosis of the first known occurrence of this disease by Doyle[1] in 1926, several outbreaks were investigated at this laboratory in the following 6 months, and the disease was confirmed in 11 counties. The origin of the first outbreak was not discovered, but in some of the later occurrences evidence was obtained that the sale of affected birds in a market was the cause of further centers of infection. From that time until 1933, no outbreaks were confirmed in Great Britain.

The outbreak of 1933 showed certain features which had not been associated with the earlier outbreaks. Publication of the observations then made has been deferred, in the hope that they could be amplified and confirmed, but the disease has not reappeared in Great Britain, and it seems desirable to place them on record.

The outbreak occurred on the premises of an owner who was developing a large business in the dressed-poultry trade. About 6,000 birds were accommodated in slatted-floor houses on free range, and at the end of August 1933, the owner found one of these birds to be sick. After death it was examined by one of the farm staff, who was unable to detect the cause of the trouble. During the previous week the birds on the farm had been regrouped, and birds from one part of the range had been transferred to another.

On the following day several more birds in the same house became affected, and 10 of these were taken by car to a laboratory. The diagnosis of the disease was not established, and a further consignment was sent to another laboratory, where T. Dalling, M.R.C.V.S., following a visit to the farm, considered the infection to be Newcastle disease.

The disease spread rapidly, and in a few days 5,000 birds had died or been destroyed as affected and the carcasses incinerated. Fortunately, no birds had left the premises, either alive or as dressed carcasses, since the outbreak commenced. Mr. Dalling notified the Ministry of Agriculture and Fisheries, and the farm was at once visited by the writer.

Large numbers of sick birds were to be seen in all parts of the free range. The symptoms noted were breathing through the mouth, a gurgling noise on inspiration, saliva hanging from the tip of the beak, and the assumption of a crouching position, with the eyelids partially or fully closed.

The total poultry stock originally numbered about 10,000. Of these, there were about 6,000 birds, 6 to 8 months old, on free range; 30 old birds in an orchard; 20 ducks; and some 4,000 chickens, from a few days to 6 weeks old, in battery brooders.

The disease had spread to the battery-brooder house, and affected chicks could be found in almost every compartment. The owner was advised to destroy all these chickens at once.

Two small breeding pens of old birds in an orchard, although tended by one of the staff who was working originally among the affected birds, were healthy and never became affected, and a group of 20 ducks, grazing the free range among the dying birds, remained quite normal.

Several carcasses of birds which had died during the day were examined at the farm, and the typical lesions associated with Newcastle disease were found. These findings, along with the symptoms seen, the rapidity of the spread of the disease, and the heavy death rate, warranted the recom-

[1] DOYLE, T. M. Jour. Comp. Path. Ther. 40:144. 1927.

mendation to the owner that all the birds should be slaughtered and the carcasses burned. The owner was advised as to the measures necessary for preventing the spread of infection to the adjoining poultry farms. Advice was also given regarding the cleansing and disinfection of the contaminated premises.

The carcasses of 4 birds which had died from the disease and 26 affected birds were removed to the laboratory by road. The post-mortem examination of the four carcasses showed the following conditions: The trachea of each bird was normal. The lungs of 2 birds were slightly congested and those of the remaining 2 birds quite normal. Petechial hemorrhages were present on the pericardial sac, heart muscle, and the mucous membrane of the proventriculus or gizzard fat. These hemorrhages were few in number and in each bird usually confined to only one or two of these sites. In all cases a catarrhal enteritis was present in the duodenum.

From these four carcasses, three fowls and five pigeons were inoculated intraperitoneally with an emulsion of liver and spleen, as shown in table 1. The inoculated birds all died within 7 days of inoculation, after showing characteristic symptoms of the disease, as seen on the farm.

As shown in the table, the mouth of an affected bird showing copious salivation was swabbed, and the material transferred to the mouth of a healthy fowl in cage 5. This bird was mouth-breathing in 6 days and died on the seventh day. Liver and spleen emulsion from this bird was passed through Seitz filters and the filtrate inoculated into fowls by the intraperitoneal route, causing typical symptoms and death within 7 days.

Two rabbits were inoculated intravenously and both remained healthy. Post-mortem examination revealed no pathological change.

Cultural work had been carried out from the commencement of the investigation, with negative results.

The 26 affected birds, which had been brought to the laboratory, were all employed in contact experiments. Two groups of 10 birds each were moved into separate pens, and in each case 10 healthy birds were placed in contact with them. A third group of 3 affected birds was placed in a pen in contact with 21 birds previously immunized against the virus strain recovered from the first British outbreak of Newcastle disease. The remaining 3 affected birds were placed in separate cages, in each case along with 1 healthy bird and 1 immunized against Newcastle disease. Table 2 shows the results of this experiment.

The three original birds which recovered in pens 1 and 2 were inoculated intraperitoneally with an emulsion of spleen and liver tissue taken from a bird that had died from fowl plague. These birds

TABLE 1.—*Results of inoculations with material from carcasses of birds dead from Newcastle disease*

Cage No.	Birds inoculated: Species	Birds inoculated: Number	Inoculum used	Route of inoculation	Quantity used	Symptoms	Result	Remarks
					Cc			
1	Fowl	3	Liver and spleen	Intraperitoneal	2	Typical	All died in 7 days.	One bird showed copious salivation; used to inoculate bird in cage 5.
2	Pigeon	5	do	do	1	do	do	
3	Rabbit	1	do	Intravenous	0.5	None		Remained healthy.
4	do	1	do	do	1	do		Do.
5	Fowl	1	Saliva from 1 bird in cage 1.	Mouth (swabbed)	2	Typical	Died in 7 days.	Liver and spleen emulsion prepared from this carcass and filtered by means of a Seitz filter.
6	do	3	Seitz filtrate of liver and spleen of No. 5.	Intraperitoneal	3	do	do	

TABLE 2.—*Contact experiments with affected birds brought from the farm*

Group	Affected birds	Fate of affected birds	Healthy birds in contact	Fate of healthy birds	Immune birds in contact	Fate of immune birds
	Number		*Number*		*Number*	
Pen:						
1	10	8 died; 2 affected but recovered	10	10 died	0	
2	10	9 died; 1 affected but recovered	10	9 died; 1 affected but recovered	0	
3	3	3 died	0		21	No symptoms.
Cage:						
7	1	Died	1	Died	1	Do.
8	1	do	1	do	1	Do.
9	1	do	1	do	1	Do.

and two control fowls were found dead on the third day.

It had now been shown that the disease could be transmitted by inoculation or contact, reproducing the symptoms, lesions, and death rate associated with Newcastle disease. Pigeons were successfully infected and rabbits remained normal after inoculation. All microscopic examinations of blood and cultural work were negative, demonstrating the absence of fowl cholera. The tracheae of all the birds examined were normal, which showed that the infection was not infectious laryngotracheitis.

Finally, the disease could not be transmitted by contact to birds which were immune to the original strain of Newcastle disease, and fowls that had recovered from the disease were still fully susceptible to fowl plague.

These facts enabled us to confirm the original diagnosis of Newcastle disease.

Visits were paid to the farm from time to time, and on one of these occasions, in October, the owner stated that 14 days previously he had purchased 1,500 day-old chicks and placed them in the battery. This procedure was contrary to the advice that he had been given. Within a week of their arrival, symptoms said to be exactly the same as those seen in the original outbreak were noticed, and all 1,500 chicks were killed and burned. This result suggested that the virus had remained viable in the batteries for a period of 7 weeks. On inspection of the brooder house it was seen that the batteries, although stated to have been cleansed and disinfected after the first outbreak and not subsequently used, were very dirty, and it was quite evident that the cleansing and disinfection had been most inefficiently carried out. Eventually, at a subsequent visit, inspection of the plant showed that further cleansing had been carried out very thoroughly.

The incubation of eggs was recommenced in the first week of November, and the resulting chicks and others purchased as day-olds were accommodated in the battery plant and kept in the slatted-floor houses which had been moved, after cleansing and disinfection, to clean ground. No further incidence of the disease was detected.

The birds used at the laboratory to confirm the diagnosis were all about 6 months old. In further experiments which were carried out immediately afterward, a group of older birds was used and many of these failed to react with the customary symptoms. Groups of 6-month-old birds were then used and the virus transferred in them to the sixth passage, each inoculation producing the typical symptoms and lesions in all birds. It would appear, therefore, that in the early passages this virus, although giving excellent results when inoculated into young birds, failed to infect hens from 2 to 3 years old. This finding is in agreement with that on the farm of origin, where 30 old birds never showed any sign of infection. This character of the virus in later passages, however, disappeared, and today it will infect young and old birds equally well.

Work carried out subsequently at the laboratory showed that ducks could not be infected with this virus. Three groups, each consisting of 10 ducks, were inoculated intraperitoneally, intravenously, and intramuscularly, respectively, and failed to show symptoms, all remaining healthy. Some of these ducks received intraperitoneally 5 cc of an emulsion of liver, spleen, and mouth exudate. Hens used as controls were inoculated similarly, and all died within 7 days.

Ducks placed in contact with infected hens showed no symptoms. These experiments, together with the fact that the 20 ducks running with the infected flock on the farm escaped the disease, indicate that these birds have a strong resistance to the disease.

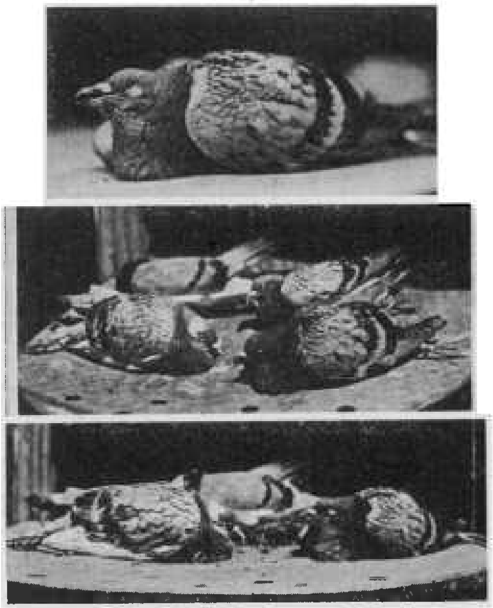

FIGURE 1.—Pigeons affected with Newcastle disease. Typical symptoms shown are breathing through the mouth, drooping of the wings, paralysis of the legs, and a sleepy appearance.

Young pigeons have been recorded as being distinctly helpful in differentiating between the viruses of Newcastle disease and fowl plague. Doyle[2] records the susceptibility of these birds to artificial infection with the virus of Newcastle disease and states that the principal symptoms exhibited are drooping of the wings and paralysis of the legs. Picard[3] noticed no mouth discharges or dyspnea in these birds, but in addition to the symptoms noted by Doyle, mentions dullness and somnolence.

[2] DOYLE, T. M. Jour. Comp. Path. Ther. 40:154. 1927.

[3] PICARD, W. K. Dept. Agr., Indus. and Commer. Dutch East Indies, Vet. Bull. 65, p. 31.

Several groups of pigeons from 3 to 5 months of age were inoculated intraperitoneally with an emulsion of liver, spleen, and mouth exudate. Figure 1[4] illustrates very well the symptoms produced, viz, drooping of the wings, paralysis of the legs, breathing through the mouth, and a sleepy appearance due to the eyelids being partially or fully closed.

SUMMARY

The largest known outbreak of Newcastle disease on a single farm in Great Britain is here recorded. The disease spread with great rapidity, and in a few days 5,000 birds were dead or affected and the carcasses incinerated.

Young fowls on range were particularly susceptible, and also chickens up to 6 weeks of age in battery brooders. Day-old chicks placed in dirty battery brooders 7 weeks after the removal of the infected chicks are stated to have become infected.

Two breeding pens of older birds, in an orchard adjoining the free range on which were the affected birds, did not become affected, although before the diagnosis was made the attendant was walking among the affected birds on his way to the breeding pens. Similarly, in the early experimental passages of the virus, some old birds were found to be insusceptible. After several artificial passages of the virus, both old and young birds were readily infected. Twenty ducks on free range with the affected birds did not show symptoms of the disease and remained healthy. Experimentally, it proved impossible to infect ducks at the laboratory, either by inoculation or contact. Pigeons were successfully infected with the virus by inoculation and showed drooping of the wings, paralysis of the legs, breathing through the mouth, and partial or full closure of the eyelids.

The origin of the infection in this outbreak could not be discovered.

ZUR BEHANDLUNG DER CORYZA UND DER TRACHEITIS DES HUHNES DURCH CHLORGAS

Von TZT. DR. JOHANN RUDOLF, *Leiter des vet. hyg. Lab. der Landeshauptmannschaft N.D.—Wien, Deutschland*

Die Coryza des Huhnes ist in den Farmen der Ostmark des großdeutschen Reiches stark verbreitet. Die bäuerlichen Geflügelhaltungen sind von dieser Krankheit meist verschont. Die Schäden, welche der Geflügelwirtschaft durch diese Krankheit zugefügt werden, sind bedeutend, weshalb ich mich schon seit Jahren bemühte, eine brauchbare Behandlung dieser Krankheit zu finden, da ich mit den bekannt gewordenen Behandlungsmethoden, besonders in größeren Farmen, befriedigende Heilerfolge nicht erzielen konnte.

Ehe ich auf die neue Behandlungsmethode eingehe, soll kurz die bis jetzt geübte und empfohlene Therapie der Coryza infectiosa des Huhnes angeführt werden. T. van Heelsbergen sagt in seinem Handbuch der Geflügelkrankheiten (1929), daß es bis jetzt kein sicher wirkendes Arzneimittel gegen den ansteckenden Schnupfen der Hühner gibt, da im Institut für infektiöse Tierkrankheiten zu Utrecht mit sämtlichen in der Literatur empfohlenen Mitteln kein Heilerfolg erzielt werden konnte. Cernaianu und C. Schlenker berichteten über ausgezeichnete Heilerfolge durch intramuskuläre Injektionen von 40 Prozentiger Urotropinlösung in Aqua dest. in einer Menge, daß auf 1 kg Körpergewicht 1 g Urotropin kommt, nicht nur bei der Geflügelpocken-Diphtherie sondern auch beim ansteckenden Schnupfen. Fleischhauer (1932) konnte bei Junghühnern mit der Urotropinbehandlung keine befriedigenden Erfolge erzielen. Bei über 1 Jahr alten Tieren sah er eine günstige Beeinflussung der Krankheit. In fortgeschrittenen Fällen versagte auch bei älteren Hühnern diese Behandlung vollständig. Nach Peymann muß die Bekämpfung der Krankheit mit der Beseitigung der Haltungsfehler und Verabreichung einer kräftigen Fütterung beginnen, da nach seiner Ansicht der infektiöse Schnupfen der Hühner in direktem Zusammenhange mit Erkältungsursachen stecht, wie mangelhafte Ställe mit undichten Wänden, unsachgemäße Auslaufklappen, schlecht schliessende und schlecht eingebaute Fenster und Türen, kalte Fußböden, feuchte Einstreu und Ausläufe mit schlechtem Windschutz. Er behandelt die Krankheit, indem er die Nasenlöcher der erkrankten Tiere mit Zellstoffwatte gründlich ausdrückt und die Nasenhöhle mit Chinosolwasser (1:1000) wäscht. Beläge in den Augenhöhlen und der Mundhöhle entfernt er. Ins Trinkwasser gibt er zu 100 Liter Wasser 1 Liter Sulfoliquid D.S. Sobald die Tiere abends die Sitzstangen aufgesucht haben, läßt er sie mit Streumianin vernebeln ($\frac{1}{2}$–1 Gramm pro Tier). Das Streumianin soll an 10 aufeinander folgenden Abenden, dann dreimal in Abständen von 2 Tagen und schließlich dreimal in Intervallen von 3 Tagen zur Anwendung kommen. Der Stall soll täglich gründlich desinfiziert werden. Die Behandlungsdauer beträgt nach Peymann 3–4 Wochen. Hagemeister glaubt,

[4] The author is indebted to A. Norman, chief technical assistant, for the excellent photographs.

daß er in einem Hühnerbestande durch wochenlange Verabreichung von 2 Prozent Sulfoliquid D.S. im Trinkwasser den Verlauf der Diphtherie und des Schnupfens günstig beeinflussen konnte und daß durch Sulfoliquid die Legetätigkeit gesteigert worden sei.

Nun ist in der Tierärztlichen Rundschau 1931, Heft 7 eine Arbeit des russischen Tierarztes W. Tscheredkow der Tierärztlichen Hochschule in Leningrad erschienen, der beim kontagiösen Schnupfen der Kaninchen durch die Behandlung mit Chlordämpfen ausgezeichnete Heilerfolge hatte. Zu dieser Behandlungsmethode war er durch eine Mitteilung des Professors Tarassewitsch über die Verwendung von Chlordämpfen bei der Grippe des Menschen angeregt worden. Nach den Angaben Tscheredkows sollen in Amerika schon seit 1922 Chlorinhalationen in großem Ausmaße ausgeführt worden sein; ob beim Menschen oder Tiere und bei welchen Krankheiten war aus der Arbeit nicht ersichtlich. Tscheredkow erzeugte die Chlordämpfe aus chemisch reiner, konzentrierter Salzsäure und Kalium hypermanganic. nach folgendem chemischen Prozesse:

$$2KMnO_4 + 16\ HCl = 2KCl + 2\ MnCl_2 + 8\ H_2O + 5\ Cl_2$$

Seine Versuche führte er in einem Raume mit ca 30 m³ Rauminhalt bei geschlossenen Türen und Fenstern derart aus, daß in ein Mensurglas 10 cm³ chemisch reine, konzentrierte Salzsäure und 2 g Kalium hypermanganic. gegeben wurden. Bei sehr feuchter Luft in diesem Raume konnte auch mit der halben Dosierung das Auslangen gefunden werden. Das Glas mit den Chemikalien wurde in der Mitte des Raumes 1 m über den Tierkäfigen aufgestellt. Die chlorhaltige Luft wurde 40-60 Minuten auf die erkrankten Kaninchen einwirken gelassen. Während der Begasung verhielten sich die Tiere im Allgemeinen ruhig, es war lediglich häufigeres Niesen zu hören. Der Autor hat im ganzen 340 erkrankte Tiere verschiedener Züchter an verschiedenen Orten nach dieser Methode behandelt, wobei nur in einem einzigen Falle das Verfahren ein zweites Mal wiederholt werden mußte. Er glaubt, daß die Wiederholung nur derhalb notwendig wurde, weil während der Behandlung die Türe zum Inhalationsraum wiederholt geöffnet worden war. Nach Beendigung der Begasung wurden stets die Türen und Fenster geöffnet. Das Allgemeinbefinden der Tiere besserte sich bereits am Tage nach der Behandlung, das Niesen wurde seltener und 3-6 Tage später war auch der Nasenausfluß verschwunden, die Freßlust kehrte zurück und die Tiere nahmen wieder normal an Gewicht zu. Nachdem bezüglich der Aetiologie der kontagiösen Rhinitis sowohl beim Kaninchen als auch beim Huhn keine einheitliche Auffassung herrscht und die klinischen Erscheinungen bei beiden Tierarten eine gewisse Uebereinstimmung haben, hielt ich es für angebracht, die einfach auszuführende Chlorbegasung zur Bekämpfung des Schnupfens der Hühner zu versuchen, dies umsomehr, als eine derartige Behandlung sich besonders leicht für eine Massenbehandlung eignen würde.

EIGENE VERSUCHE

Vor Anwendung des Chlorbegasungsverfahrens in der Praxis wurde zuerst ein Versuch im Laboratorium zur Feststellung der Empfindlichkeit des Huhnes gegen das Chlorgas angestellt. Den praktischen Verhältnissen Rechnung tragend, gab ich ein gesundes Huhn in eine einfache Kiste mit ca $\frac{1}{2}$ m³ Rauminhalt. Um die Kiste einigermaßen abzudichten, wurde sie mit einem Jutesack umhüllt. In die Kiste kamen in einer Mensur, die an der Kistenwand mit Draht befestigt wurde, 2 g Kalium hypermanganic. und 10 cm³ konzentrierte, reine Salzsäure, also eine Menge, die nach den Angaben Tscheredkows zur Vergasung eines Stalles von ca 30 m³ Rauminhalt ausgereicht hätte. Das Huhn vertrug diese Begasung in den ersten 30 Minuten ohne besondere Reaktionserscheinungen. Nach 45 Minuten Gaseinwirkung erfolgte der Tod. Ehe zur Begasung der Tiere im Stall übergegangen wurde, wurden nun zwei schwer erkrankte Hühner in der gleichen Kiste durch 15 Minuten dem aus 1 g Kalium hypermanganic. und 5 g HCl entwickelten Chlorgas ausgesetzt, was von den Tieren reaktionslos vertragen wurde. Der gleiche Versuch wurde mit der doppelten Menge der Chemikalien mit 2 anderen Tieren unter Beibehaltung der gleichen Einwirkungsdauer wiederholt. Diese Tiere zeigten nach der Behandlung starke Atemnot und eines ging am 3. und das zweite am 4. Tage nach der Behandlung ein.

Aus diesen Vorversuchen schloß ich, daß bei der Verwendung von 2 g Kalium hypermanganic. und 10 cm³ Salzsäure auf ca 30 m³ Luftraum kaum eine Schädigung des Allgemeinbefindens der Hühner bei einer 30-40 Minuten dauernden Begasung auftreten dürfte.

Nun wurde seit dem Jahr 1933 die Chlorbegasung den Farmern beim Schnupfen der Hühner und in einigen Fällen auch bei Tracheitis empfohlen. Die gemeldeten Erfolge befriedigten in den meisten Fällen. Versager sind aber auch vorgekommen.

Die Behandlung selbst wurde derart durchgeführt, daß nach Ermittlung des Rauminhaltes des Begasungsraumes zuerst die Menge der zu verwendenden Chemikalien bestimmt wurde. (2 g Kalium hypermanganic. und 10 g HCl auf 30 m³ Rauminhalt.) Die gesunden und kranken Tiere wurden in den Behandlungsraum gebracht, dann wurden die Fenster und Türen geschlossen. Je nach der Größe des Raumes wurden an mehreren Stellen Glasgefäße mit den entsprechenden Mengen von Kalium hypermanganic. ungefähr 1 Meter über dem Boden aufgestellt und dann darauf die erforderliche Menge Salzsäure gegossen. Die nötige zum Erfolg führende Gasmenge war dann vorhanden, wenn beim längeren Verweilen im Stalle beim Menschen Hustenreiz ausgelöst wurde. Das Gas wurde 30 Minuten einwirken gelassen. Zeigten sich aber gelegentlich stärkere Unruheerscheinungen, so wurde die Begasung unterbrochen und die Tiere sofort ins Freie getrieben. Die Begasung wurde an 2–8 auf einander folgenden Tagen wiederholt.

Unter den behandelten Beständen befanden sich auch zwei Farmen mit größeren Verlusten infolge hochgradiger Tracheïtis. In einer dieser Farmen herrschte die Erkrankung besonders stark unter den Junghühern. Nach der ersten Begasung ist nur mehr ein Huhn eingegangen. Nach 14 Tagen erschienen alle erkrankten Tiere gesund, nachdem noch weitere 5 Begasungen ausgeführt worden waren. Erkrankungen sind in diesem Bestande in der Folge nicht mehr vorgekommen.

Ueberängstliche Besitzer, die das Gas nur einige Minuten auf die Tiere einwirken gelassen hatten, konnten trotz wiederholt vorgenommener Behandlungen keine Heilwirkung erzielen.

Hervorgehoben muß auch werden, daß zur Erzielung eines Erfolges die Luft im Behandlungsraum nicht zu trocken sein darf. Ist dies der Fall so kann vor der Begasung der Feuchtigkeitsgehalt der Luft durch Verdunstung von Wasser erhöht werden.

Schließlich wird bei der Anwendung des Chlorgases zur Behandlung des Schnupfens auch noch darauf zu achten sein, welche Aetiologie die Krankheit in dem zur Behandlung kommenden Hühnerbestande hat. Das mir zu Bearbeitung zugängliche Material stammt aus den Gauen Niederdonau und Wien. Bei diesem Untersuchungsmaterial konnte ich feststellen, daß in erster Linie Erkältungen, wodurch verschiedene ubiquitäre Mikroorganismen der Atmungsorgane virulent werden, zu den Erscheinungen der Coryza führen. Die Krankheit tritt hier hauptsächlich bei ungünstigen Witterungsverhältnissen in unhygienischen Stallungen und in Farmen mit nicht windgeschützter Lage auf. In den Fällen, wo die primäre Ursache in einer Verkühlung der Tiere zu liegen schien, hat die Chlorbegasung die größten Erfolgsaussichten gehabt. Jedenfalls habe ich auch Gelegenheit gehabt, öfter *pasteurella*artige Mikroorganismen bei typischen Schnupfenfällen in Reinkultur zu finden. Die Krankheit selbst konnte ich bei künstlicher Infektion mit diesen Reinkulturen nicht erzeugen. Leider hatte ich nicht Gelegenheit den Wert der Chlorbehandlung in diesen Fällen zu prüfen. Endlich sind mir noch Bestände untergekommen, in denen die Chlorbegasung in Verbindung mit der Diphtherieimpfung zur Bekämpfung der Krankheit angewendet wurde. Es handelte sich um jene Erkrankungsfälle, die mit Diphtherie verwechselt werden könnten. Die Membranen in der Mundhöhle und am Kehlkopf hatten aber eine mehr weißliche Farbe und hafteten der Schleimhaut nur leicht an. Ich versuchte öfter durch Verimpfung von verriebenen Membranen die Krankheit auf gesunde Hühner zu übertragen. Die Impfversuche sind für Diphtherie immer negativ verlaufen.

ZUSAMMENFASSUNG

Angeregt durch eine Arbeit des russischen Tierarztes Tscheredkow, der beim kontagiösen Schnupfen der Kaninchen mit Chlordämpfen ausgezeichnete Heilerfolge hatte, wurde versucht, ob die Chlorinhalation nicht auch für den in der Ostmark stark verbreiteten Hühnerschnupfen und für die gelegentlich auch seuchenhaft auftretende Tracheitis der Hühner eine brauchbare Behandlungsmethode darstelle.

Die Behandlung der Coryza und der Tracheitis mit Chlorgas wird vom Autor seit 1933 angewendet. Die besten Erfolge wurden erzielt, wenn die primäre Krankheitsursache (Coryza) in einer Verkühlung gelegen war.

Die Methode ist besonders für Massenbehandlungen geeignet.

Die Kosten der Behandlung sind gering, da das Gas aus billigen Chemikalien (Kalium hypermanganic. und konzentrierte Salzsäure) auf einfache Weise gewonnen werden kann.

Bei der Behandlung ist besonders darauf zu achten, daß die Chlordämpfe im Behandlungsraum in entsprechender Konzentration enthalten sind und daß dieselben genügend lange auf die Tiere einwirken gelassen werden.

Die guten Ergebnisse, die Peymann bei der von ihm angegebenen Behandlungsmethode des Schnupfens hatte, dürften zum Teil auch auf die Verneblung der Stallungen mit Streumianin, einem Präparat, das ebenfalls Chlorgas entwickelt, zurückzuführen sein.

SUMMARY

Pursuant to a report by the Russian veterinarian Tscheredkow, who obtained excellent results in the treatment of contagious colds of rabbits with chlorine gas, it was investigated whether the inhalation of chlorine gas might not also prove a suitable treatment for colds of chickens occurring frequently in the Ostmark and for fowl tracheitis that occasionally occurs in epizootic form.

The treatment of coryza and tracheitis with chlorine gas has been used by the author since 1933. Best results were obtained when the primary cause (coryza) was a cold.

The method is particularly suitable for the treatment of a large number of birds.

The cost of this treatment is low, because the gas may be produced by a simple process from cheap chemicals (potassium permanganate and concentrated hydrochloric acid).

Great care must be taken, during the treatment, that the chlorine gas in the room where the treatment takes place is of the proper concentration and that it affects the animals for a sufficient length of time.

The good results obtained by Peymann with his method for the treatment of colds may be partly due to the use of "Streumianin" which also develops chlorine gas.

RESPIRATORY DISEASES OF BIRDS

By F. R. BEAUDETTE, *Poultry Pathologist, New Jersey Agricultural Experiment Station and Rutgers University, New Brunswick, New Jersey, U. S. A.*

INFECTIOUS LARYNGOTRACHEITIS

Infectious laryngotracheitis is the most widespread respiratory disease in the United States. Gasping is a common symptom, and if a bird so affected shows blood or blood-stained mucus in the trachea, a loosely attached caseous plug in the larynx, or a croupous membrane in the trachea, a diagnosis may be made without further question. However, the eyes, nasal cavity, or sinuses may be involved in the absence of other lesions. Therefore, these cases must be differentiated from other diseases in which conjunctivitis, rhinitis, or sinusitis may be seen.

After a bacterial infection has been excluded, exudate from the questionable case should be emulsified and inoculated intratracheally into a bird known to be immune only to laryngotracheitis. A control bird also should be inoculated. If the former bird fails to contract a respiratory disease and the latter becomes infected, evidence of the presence of laryngotracheitis virus is furnished. A diagnosis of laryngotracheitis may also be made if, after complete recovery, the bird fails to show a "take" when inoculated intracloacally with a known laryngotracheitis virus. A readable take will develop in a susceptible bird in 3 to 5 days after inoculation.

Time is an important factor in the diagnosis of respiratory diseases for the reason that further spread of laryngotracheitis can be prevented by an emergency vaccination. Consequently, the least time-consuming method that will give accurate results is to be used.

Propagation of the virus on the chorio-allantoic membrane of the developing chick may be used to differentiate laryngotracheitis from bronchitis with which it may be confused. Laryngotracheitis virus produces visible lesions on the serosa and in early generations usually does not kill the embryo, whereas bronchitis virus produces no lesions on the serosa but does retard growth of the embryo and frequently kills it. Further passages of the latter virus intensify these properties.

Neutralization tests made with eggs are fairly reliable but require too much time for practical purposes. An immune bronchitis serum usually neutralizes its virus completely, but laryngotracheitis-immune serum may cause only partial neutralization which, however, is readily identified when the amount of growth in eggs so inoculated is compared with that in eggs inoculated only with virus.

The finding of intranuclear inclusions in tracheal epithelium by histological examination has been used by some investigators to diagnose laryngotracheitis.

INFECTIOUS BRONCHITIS

This virus infection is most common in chicks a few days old and may cause a high mortality. The mortality is lower in chicks infected after 3 weeks of age, and infected adults rarely die but egg production may be markedly reduced. A rapid, labored breathing is a prominent symptom in chicks, and if the bird is held to the ear cracking sounds are heard. Post-mortem examination of chicks usually shows mucus, but never blood, in the lower trachea. The bronchi may contain thick mucus or caseous plugs. The air sacs are frequently clouded or contain caseous exudate. A fibrinous exudate in the pericardial sac is not rare. In adult birds the rattling respiratory sounds may be alarming, but this symptom soon gives way to a nasal discharge that disappears after a few days. In this stage, however, the disease may be confused with similar cases of laryngotracheitis.

In making a diagnosis, the methods employed for the differentiation of laryngotracheitis are used, that is, exudate is emulsified and inoculated intratracheally into birds immune only to bronchitis, or the recovered bird may be tested for immunity to an intratracheal inoculation of known bronchitis virus. In fact, when a differentiation is being made between bronchitis and laryngotracheitis, birds immune to each disease are inoculated with the unknown inoculum or recovered birds are tested against each virus.

The course in laryngotracheitis and bronchitis is short in contrast with the prolonged course usually seen in coryza and other diseases.

CORYZA

Clinically, three types of coryza have been described by Nelson, viz, coryza I, having a short incubation period and a short course; coryza II, having a long incubation period and a long course; and coryza III, having a short incubation period and a long course. Aetiologically, however, two agents may be involved. The rhinitis, sinusitis, conjunctivitis, and frequently a tracheitis that provokes mild gasping symptoms make it possible to confuse the disease with other infections. However, the exudate in coryza usually has a disagreeable odor, and a swelling of the periorbital tissues or wattles often occurs so that these features may be of assistance in making a differentiation. A specific bacillus, *Hemophilus gallinarum,* is associated with the types of coryza having a short incubation period, but in the type having a long incubation period Nelson has described Gram-negative coccobacilliform bodies in the exudate. This organism will not grow in the usual media but can be propagated in tissue culture or in the chorio-allantoic membrane of very young embryos (4 days old).

Diagnosis of the bacillary type of coryza depends on isolation of the organism on blood agar plates sealed with modeling clay or incubated in an atmosphere of carbon dioxide. Occasionally pure cultures can be obtained from the sinus. The absence of this organism in cases that are coryza in type and in which no other infectious agent can be found suggests the type associated with the coccobacilliform bodies. The diagnosis is confirmed by microscopic examination, by cultivation in tissue cultures or on the chorio-allantoic membrane, or on clinical grounds that the exudate produces a coryza after a long period of incubation in which no other infectious agent can be demonstrated.

LOCALIZED FOWL CHOLERA AND STREPTOCOCCUS INFECTION

The fowl cholera organism is frequently responsible for localized infections of the eyes, sinus, or nasal cavity. Gasping symptoms are not seen in these cases. This type of disease occurs in the more resistant birds of a flock in which others die of the septicemic form of the disease. In rare cases a hemolytic streptococcus may cause similar cases but in these there is less exudation, more swelling of the tissues, a longer course, and frequent exacerbations.

The fowl cholera organism is easily isolated from hemolyzed blood agar plates streaked with a swab infected from the localized lesion. The organism is identified by fermentation reactions. The streptococcus is isolated in the same manner, but whole-blood agar plates are used so that the zone of hemolysis can be used to identify the colony.

FOWL POX

Fowl pox may be considered a respiratory disease only to the extent that in some cases a caseous plug forms in the larynx or there may be infection of the conjunctiva producing lesions not unlike those of other respiratory disease. The absence of skin lesions may not suggest fowl pox; however, if the laryngeal plug is firmly attached, pox may be suspected. In any event, when an emulsion of exudate is smeared onto the scarified comb of a susceptible bird the easily diagnosed skin lesions of fowl pox will develop in 5 to 7 days if this virus is present.

VITAMIN A DEFICIENCY

In the absence of gasping symptoms, the presence of a white, easily removed mass of caseous material in the conjunctival sac is suggestive of vitamin A deficiency. The diagnosis is confirmed by the presence of nodules on the mucosa of the esophagus and by functional changes in the kidneys. Visceral gout may be found in advanced cases.

DISEASES CAUSED BY GAPEWORMS AND AIR-SAC MITES

Gapeworms are not so common as formerly, but when present the gasping symptom is highly suggestive of laryngotracheitis. The parasite is most common in pheasants, and this species is also susceptible to laryngotracheitis. The parasite is easily evidenced by a post-mortem examination.

In rare cases an infestation of air-sac mites is severe enough to cause an accumulation of mucus in the trachea and provoke gasping symptoms. The mites in the mucus of the trachea are not visible, but a perceptible heavy infestation of the abdominal air sacs suggests the desirability of a microscopic examination of the tracheal mucus.

In diseases caused by these two parasites there is no exudate in the eyes, sinuses, or nasal cavity.

PULLORUM DISEASE AND ASPERGILLOSIS

Labored breathing in young chicks is suggestive of bronchitis, but this symptom may be due to nodules in the lungs caused by pullorum disease or aspergillosis. In the former disease nodules may also be found in the myocardium or in the wall of the gizzard. A bacteriological examination confirms the diagnosis.

QUAIL BRONCHITIS

In very young quail a disease exists that is clinically similar to bronchitis in chicks. Limited experiments indicate that the causative agent is a virus. The disease, however, is not transmissible to chickens nor is the bronchitis of chickens infectious for quail. An attack of the disease produces immunity. The mortality may be well over 50 percent.

FOWL PARALYSIS

Obviously fowl paralysis is not a respiratory disease. Nevertheless, when the vagus nerve becomes infiltrated an arhythmic extension of the head and neck, as in gasping, may be seen. The affected bird is usually 3 months or more of age.

An autopsy shows the respiratory tract free of exudate, and visible enlargement of the vagus confirms the diagnosis.

MISCELLANEOUS CONDITIONS

There are miscellaneous conditions associated with gasping symptoms, but these are of sporadic occurrence and therefore can be ruled out as specific infections. However, the existence of new specific respiratory diseases should never be overlooked. Gasping is said to be a common symptom in the so-called Newcastle disease. However, as this infection has not yet invaded the United States, for the present at least it need not be considered in the differential diagnosis of this group of diseases.

SUMMARY

Respiratory diseases or affections provoking gasping symptoms or actual changes in the upper respiratory tract may be caused by viruses, bacteria, fungi, parasites, or vitamin deficiency. Consequently, an accurate diagnosis requires cross-immunity tests, animal inoculations, cul-

tivation, or neutralization tests in the case of such virus diseases as laryngotracheitis, bronchitis, and fowl pox.

The diagnosis of bacterial diseases, such as coryza, localized fowl cholera and streptococcus infections, and pullorum disease necessitates a bacteriological examination of organs or exudates. In every case the medium employed should satisfy the growth requirements of the organism in question. The same procedure is used for the diagnosis of the fungus disease aspergillosis.

A simple post-mortem examination suffices for the diagnosis of gapeworm infestation, vitamin A deficiency, lymphomatosis of the vagus, and to some extent air-sac mite infestation.

Microscopic methods are employed to identify air-sac mites in tracheal mucus, intranuclear inclusions in tracheal epithelium of laryngotracheitis infection, the coccobacilliform bodies in the exudate of the coryza of slow onset, and finally to confirm the infiltrations of an enlarged vagus nerve.

TRICHOMONADEN ALS KRANKHEITSERREGER BEIM GEFLÜGEL

Von DOZENT VETERINÄRRAT DR. J. SCHAAF, *Direktor des Staatlichen Veterinäruntersuchungsamt Arnsberg, Westfalen, Deutschland*

Untersuchungen über das Vorkommen und die pathogene Bedeutung der zu den Protozoen in die Klasse der Flagellaten gehörenden Trichomonaden beim Menschen und insbesondere bei den Haustieren sind in den letzten Jahren von verschiedenen Seiten in grösserem Umfange durchgeführt worden. Auf diese Untersuchungen und auf klinische Erfahrungen gestützt, bricht sich entgegen der früher fast allgemein vertretenen Ansicht der Harmlosigkeit der Trichomonaden für die menschliche und tierische Gesundheit hinsichtlich einiger Trichomonadenarten, insbesondere der Geschlechtstrichomonaden des Rindes und Menschen, sowie der Taubentrichomonaden (*Tr. columbae*) mehr und mehr die gegenteilige Erkenntnis Bahn.

PATHOGENE GEFLÜGELTRICHOMONADEN

Die Pathogenität der bei den verschiedenen Hausgeflügelarten vorkommenden Trichomonaden ist, abgesehen von den Trichomonaden der Taube—*Trichomonas columbae*—noch nicht ausreichend geklärt. So liegen Mitteilungen über Trichomonaden als Krankheitserreger bei Hühnern, Hühnerküken und Truthühnern bisher nur spärlich und nicht beweiskräftig genug vor. In der Regel wurde lediglich aus der Anwesenheit von Trichomonaden in den Organen oder Entzündungsmassen erkrankter Tiere auf eine ursächliche Bedeutung der Trichomonaden beim Zustandekommen der Krankheit geschlossen. Aufschluss hierüber können aber nur planmässige Untersuchungen über das Vorkommen von morphologisch und biologisch genau erfassten Trichomonaden bei gesunden und kranken Tieren liefern, insbesondere muss aber der Nachweis der pathogenen Wirkung der Trichomonaden durch den mit Reinkulturen ausgeführten Infektionsversuch geliefert werden. Derartige Untersuchungen sind bisher mit den Trichomonaden der Taube und des Haushuhnes ausgeführt worden.

DIE TRICHOMONIASIS ("GELBER KNOPF") DER TAUBEN

Bezeichnung und Wesen.—Die Trichomoniasis der Tauben auch als Gelber Knopf, Pseudokrupp, Flagellaten-Diphtherie, Mond- und keeltrichomoniasis, Geel of mondswam, Lebertrichomoniasis, Enterohepatitis bezeichnet, ist eine wegen ihres grossen wirtschaftlichen Schadens als Jungtierseuche in Züchterkreisen gefürchtete durch Trichomonaden verursachte Krankheit, bei der es zu einer umfangreichen fibrinös-diphtheroiden Entzündung der Schleimhaut des oberen Verdauungweges, insbesondere des Rachens, sowie der Nebenhöhlen des Kopfes und zur Bildung nekrotischer Herde in der Leber und anderen inneren Organen kommt.

Vorkommen.—Die Trichomoniasis kommt fast nur bei Taubenküken vor und ist in den verschiedensten Ländern der Welt beschrieben worden, so in Italien, Südafrika, Ungarn, Ostindien, Deutschland, Holland und in USA.

Aetiologie.—Ursächlich kommt *Trichomonas columbae-Trichomonas hepatica* in Betracht. Die Angaben über ihre Morphologie gehen zum Teil recht erheblich auseinander. Nach eigenen Untersuchungen besitzen die Rachentrichomonaden der Tauben immer 4 freie, paarweise gleichlange Geisseln, eine undulierende Membrane mit Randgeisseln (keine Schleppgeissel) und Basalfibrille, einen durch den ganzen Körper sich erstreckenden und aus diesem etwas herausragenden Achsenstab sowie eine in umgekehrter Richtung dazu verlaufende Körperfibrille. Sämtliche Fibrillen, Geisseln und der Achsenstab gehen von dem Basalkörper aus. Diese Trichomonade kommt weit verbreitet auf der Rachen- und Schlundschleimhaut bei kranken, aber auch nicht selten bei gesunden Tauben vor, die als Keimträger betrachtet werden müssen. Der naheliegende Gedanke, *Trichomonas columbae* aus diesem Grunde als harmlosen saprophytären Parasiten anzusehen, ist durch gelungene künstliche Übertragungsversuche mit Reinkulturen von Trichomonaden entkräftet, durch die sich die künstliche Krankheit mit allen ihren verschiedenen Erscheinungsformen erzeugen lässt. Im Tierkörper ist *Trichomonas columbae* auf der Schleimhaut des Verdauungsapparates und der Nebenhöhlen des Kopfes daneben in den inneren Organen, vor allem in der Leber und im Blute erkrankter Tiere nachgewiesen worden. Im Freien kann sich die Taubentrichomonade längere Zeit lebens- und infektionsfähig erhalten. Beziehungen zu den Trichomonaden anderer Tiere und des Menschen sind bisher nicht ermittelt worden, wenn auch die Pathogenität von Trichomonas columbae nach parenteraler Einverleibung bei kleinen Versuchstieren (Mäuse, Meerschweinchen) feststeht. Rein morphologisch lassen sich die bei den einzelnen Tieren und beim Menschen, ja bereits die in den verschiedenen Organen des gleichen Tieres, vorkommenden Trichomonaden scharf voneinander trennen, ohne dass etwa fliessende Übergänge von einer Trichomonadenform zur anderen erkennbar sind.

Die künstliche Übertragung der Krankheit mit Reinkulturen von *Trichomonas columbae* lässt sich sowohl durch Fütterung als auch auf parenteralem Wege (subkutane, intramuskuläre, intravenöse, intraabdominale, intrahepatale, omphalogene Infektion) besonders bei Jungtieren hervorrufen.

Die natürliche Übertragung erfolgt sehr wahrscheinlich beim Füttern der Taubenküken durch die klinisch gesunden Elterntiere, die die Trichomonaden in ihrer Rachenhöhle, im Schlund und Kropf beherbergen. Es erkranken in der Regel nicht alle Jungtiere eines Bestandes, zuweilen auch nicht sämtliche Tiere eines Geleges. Unter den Alttieren können die Trichomonaden beim "Schnäbeln" oder durch Aufnahme infizierten Trinkwassers verbreitet werden. Epizootologische Erfahrungen haben gezeigt, dass Jungtiere bestimmter Elterntiere oder eines einzelnen Elterntieres besonders häufig erkranken, eine Tatsache, die entweder auf die Elterntiere als Keimträger oder auch auf erbmässig bedingte, konstitutionelle Schwäche hinweist. Eine unmittelbare Übertragung der Trichomonaden durch das Brutei auf das Junge kommt nicht in Frage, weil sich Trichomonaden im Ei nicht lebensfähig erhalten können. Zweifellos wirken sich prädisponierende Einflüsse auf das Zustandekommen der Krankheit stark aus. Als solche sind vor allem unhygienische, kalte, vor Zugluft ungeschützte, dunkle und unsaubere Ställe und Erkältungen zu nennen, da sich die Erkrankungsfälle in den kalten und feuchten Monaten in einem verseuchten Bestande häufen.

Krankheitserscheinungen.—Die Trichomonaden verursachen vor allem an ihrem Lieblingssitz auf der kutanen Schleimhaut des Verdauungsapparates—Rachen-, Schlund-, Kropf- und Schnabelschleimhaut—eine diphtheroide, besonders im Rachen schnell um sich greifende Entzündung bei Jungtieren meist schon im Alter von ein bis mehreren Wochen. Die Entzündung führt in kurzer Zeit zur Bildung umfangreicher, blumenkohlähnlich stark zerklüfteter, bröckeliger, nekrotischer Massen und damit zu einer meist bereits äusserlich, ohne Öffnung des Schnabels sichtbar werdenden, knotenartigen Verdickung der oberen Halsgegend ("gelber Knopf"). Bei gewaltsamer Entfernung der Entzündungsmassen bleibt eine stark blutende, höckerige, tiefreichende Geschwürsfläche zurück.

Zum Krankheitsbild der Trichomoniasis gehört ausserdem die "Nabeldiphtherie", eine von der Nabelwunde ausgehende nekrotisierende Entzündung des erbsen bis taubeneigrossen, verdickten und vorgewölbten Nabels, der mit einer trockenen, bröckeligen strukturlosen Masse angefüllt ist. Diese Masse bricht nach aussen durch die Haut hindurch und zeigt dann eine in Farbe und Aussehen blumenkohlähnliche, manchmal auch mit konzentrisch angeordneten Ringen versehene Oberfläche. Der Prozess beginnt meist schon bei Küken im Alter von mehreren Tagen, zunächst als kleine, mehr fühl- als sichtbare Verdickung inmitten des nach dem Schlüpfen mit ringförmigem Walle und zentraler Vertiefung ausgestatteten Nabels. Die Verdickung dehnt sich dann besonders nach dem Rande zu, aber auch in die Tiefe erheblich aus, so dass ein Abheben von den Baucheingeweiden nicht mehr möglich ist (Bauchfellentzündung). Die Veränderung fühlt sich zunächst derb, später hart und deutlich von der gesunden Umgebung abgesetzt an. Im Falle der nicht seltenen spotanen Heilung wird dann der Inhalt des Nabels nach aussen abgestossen oder kann auch leicht ausgedrückt werden.

Das Allgemeinbefinden der kranken Taubenküken ist mehr oder weniger gestört. Häufig tritt durch schlechte Fresslust und durch die mechanische Behinderung der Futteraufnahme Abmagerung, ferner ein Darmkatarrh hinzu, hin und wieder auch bei Erkrankung der Lungen Atemnot und beschleunigte Atmung. Die Sterblichkeitsziffer bei Jungtieren kann bis zu 80 v.H. und darüber betragen. Bei Alttieren entwickeln sich nur in vereinzelten Fällen geringe fibrinöse Entzündungsprozesse der kutanen Schleimhaut des Verdauungsapparates.

Pathologisch-anatomisch findet man die beschriebenen pseudomembranösen, diphtheroiden, herdchen- oder knotenförmigen bezw. diffusen Entzündungserscheinungen auf der kutanen Schleimhaut des Verdauungskanals (Rachen, Schlund und Kropf) und am Nabel. Nicht selten sind auch die Nebenhöhlen des Kopfes mit gelben Entzündungsmassen angefüllt. Daneben treten nerotische Herde in der Leber, den Lungen, der Bauchspeicheldrüse, sowie fibrinös-eitrige Entzündungsmassen in den Lungen und Luftsäcken, der Leibeshöhle und im Herzbeutel auf. Ausserdem sind Abmagerung, Schwellung der Milz und ein Darmkatarrh zu verzeichnen.

Die Diagnose hat auf Grund des klinischen, pathologisch-anatomischen sowie histologischen Befundes zu erfolgen und wird durch den mikroskopischen oder kulturellen Nachweis der Trichomonaden gesichert. Die Trichomonaden werden wegen ihrer besonders im Organdetritus schwierigen färberischen Darstellbarkeit (Färbung mit Giemsa-Farblösung oder mit verdünnten einfachen Farblösungen) am besten im Vitalpräparat aus den entzündlichen Massen, in dem sie bei Verwendung frischen Materials durch ihre lebhafte Beweglichkeit auffallen, nachgewiesen. Die Kultur gelingt am besten auf dem Locke-Ei-Serum-Nährboden nach Boeck und Drbohlav oder auf dem Nährboden nach Dobell und Laidlaw, auf dem Nährboden nach Witte oder anderen Nährböden, wie sie von Schaaf und Schmitt auf ihre Brauchbarkeit geprüft wurden.

Differentialdiagnostisch ist vor allem die Pokkendiphtherie klinisch bezw. epizootologisch durch das Fehlen von Pocken auf der Haut, das Nichterkranken erwachsener Tiere und histologisch vor allem durch den Mangel von Einschlusskörperchen auszuschliessen. Die Soorkrankheit ist durch den Nachweis der Soorpilze in den Schleimhautveränderungen zu erkennen.

Eine Immunität nach natürlicher oder künstlicher Durchseuchung ist bisher nicht festgestellt worden, jedoch besteht eine ausgesprochene Altersresistenz.

Bekämpfung.—Zur Behandlung der Trichomoniasis ist zu Beginn der Krankheit die chirurgische Entfernung der diphtheroiden Massen im Rachen (Vorsicht wegen Verblutungsgefahr) und am Nabel mit nachfolgendem Betupfen mit Jodtinktur, Jodglyzerin oder einem anderen Desinfektionsmittel zu empfehlen. Hauptwert ist auf die Vorbeuge, u.a. auf hygienische Haltung, peinlichste Sauberkeit in den Ställen und Nistplätzen, einwandfreies Futter, frisches Trinkwasser, Trinkwasserdesinfektion (0,5 Prozent Sulfoliquid, 0,5 Prozent Kupfersulfat), Schutz vor Erkältung durch warme, zugluftfreie Ställe zu legen.

TRICHOMONADEN ALS ERREGER ANDERER GEFLÜGELKRANKHEITEN

Als Erreger einer jahrelangen in einem Putenbestande bestehenden, mit Schleimhautkatarrh der oberen Verdauungswege mit "Hängekropf" verlaufenden Putenseuche stellte Volkmar eine Trichomonade fest, die er als *Trichomonas diversa* bezeichnet. Die Trichomonaden fanden sich in grosser Menge in der Schnabelhöhle, Speiseröhre, im Kropf und im Drüsenmagen, jedoch nicht im Muskelmagen und Darm.

Pathologisch-anatomisch fanden sich in der Schleimhaut der oberen Verdauungsorgane graue und graugelbliche tumorähnliche Herde, die zum Teil eine höckerige nekrotische Oberfläche aufwiesen. Im Drüsenmagen waren sie derart gross, dass sie die Nahrungsaufnahme mechanisch behinderten.

Bei Hühnern wurden Trichomonaden von älteren Autoren irrtümlich in ursächlichen Zusammenhang mit der Pockendiphtherie gebracht, weil Trichomonaden häufig in den diphtheroiden Entzündungsmassen zu finden sind. Da auch in neuerer Zeit noch die Frage aufgeworfen wurde, ob wie bei der Taube so auch beim Huhn neben der Pockendiphtherie noch eine Trichomonadendiphtherie besteht, wurden von Schaaf und Scherle 1938 systematische Untersuchungen über die Pathogenität der Hühnertrichomonaden bei Hühnern angestellt. Hierbei konnte bei Hühnern, die an den verschiedensten Krankheiten (ansteckender Schnupfen, Diphtherie, Darmentzündung u.a.) litten oder gestorben waren, eine spezifische Trichomonadenkrankheit nicht ermittelt werden. Ebenso waren durch künstliche Infektion mit bakterienarmen Kulturen von Rachen- oder Darmtrichomonaden auf dem Fütterungswege mit oder ohne oberflächliche Verletzung der Rachenschleimhaut Krankheitserscheinungen nicht auszulösen. Da sich, wie die Versuche zeigten, Trichomonaden besonders zahlreich in eitrigen oder nekrotischen Entzündungsmassen ansiedeln, wurde auch bei schnupfenund diphtheriekranken Hühnern die Frage einer Verschlimmerung des Krankheitsprozesses durch die Trichomonaden geprüft, ohne dass sich hierbei grosse Unterschiede zwischen den trichomonadenbehafteten oder -freien Versuchshühnern ergaben, so dass die Trichomonaden beim Huhne in erster Linie als harmlose Kommensalen anzusehen sind.

Bei Brieftauben beobachteten Nöller und Budgereit 1923 einen tödlichen Darmkatarrh, der anscheinend auf eine Trichomonadenart (*Octomites columbae*) zurückzuführen war.

Eine ähnliche Mitteilung über einen durch massenhaften Befall mit Trichomonaden (*Trichomonas* Eberthi und *Trichomonas anati*) bedingten Darmkatarrh bei Enten liegt von Kotlan 1923 vor.

Abschliessend ist über die Trichomonaden als Erreger von Geflügelkrankheiten festzustellen, dass sie nach dem heutigen wissenschaftlichen Standpunkt, abgesehen von der Trichomoniasis der Taubenküken, wirtschaftlich bedeutungsvolle Krankheiten nicht veranlassen. Weiteren wissenschaftlichen Untersuchungen ist es vorbehalten, noch offenstehende Fragen über Geflügeltrichomonaden, ihr Vorkommen, ihre Biologie, Infektiosität und Infektionswege zu klären. Besondere Beachtung verdient dabei die bei Protozoenkrankheiten bedeutsame "labile Infektion", die durch prädisponierende, konstitutionell und konditionell bedingte Einflüsse zur offensichtlichen Erkrankung der Tiere durch Entfaltung der Pathogenität der Trichomonaden führt.

ZUSAMMENFASSUNG

Unter den beim Hausgeflügel hauptsächlich im Verdauungsapparat weitverbreitet vorkommenden Trichomonaden sind einige als Krankheitserreger bei Tauben, Truthühnern und Enten bekannt geworden, ohne dass jedoch der Nachweis ihrer Pathogenität durch den mit Reinkulturen angestellten Tierversuch bisher immer erbracht ist. Dies trifft u.a. für die bei der Pockendiphtherie und beim Schnupfen des Huhnes festzustellenden Trichomonaden zu, die sich sekundär als saprophytäre Parasiten im eiweissreichen, abgestorbenen Gewebe ansiedeln und vermehren können. Eine spezifische Trichomonadeninfek-

tion beim Huhn, insbesondere eine Trichomonadendiphtherie, ist bisher nicht nachgewiesen worden.

Als Krankheitserreger einwandfrei erkannt ist dagegen *Trichomonas columbae*, die bei den Jungtauben die Trichomoniasis ("Gelber Knopf", Flagellatendiphtherie) auslöst. Sie verläuft unter dem Bilde einer heftigen fibrinös-diphtheroiden Entzündung der kutanen Schleimhaut des Verdauungsapparates, besonders des Rachens ("Gelber Knopf") unter Anhäufung von fibrinös-eitrigen Entzündungsmassen in den Nebenhöhlen des Kopfes, den Lungen, Luftsäcken, der Leibeshöhle und dem Herzbeutel. Zum Krankheitsbilde gehört ausserdem eine nicht selten zu umfangreicher Nekrose, Bauchfellentzündung und Sepsis führende Nabelentzündung mit nekrotischen Herden in den inneren Organen (Leber, Bauchspeicheldrüse, Lungen). Die natürliche Ansteckung kommt auf dem Fütterungswege und durch Wundinfektion (Nabelentzündung) zustande; die Infektionsquelle sind klinisch gesund erscheinende Alttiere. Der Ausbruch der Krankheit wird durch Hilfsursachen gefördert, zum Teil durch unhygienische Haltung und Fütterung, Witterungseinflüsse, polybakterielle Mischinfektion und konstitutionell bedingte Empfänglichkeit. Die Bekämpfung hat diese Hilfsursachen nach Möglichkeit prophylaktisch abzustellen; ausserdem empfiehlt sich eine Trinkwasserdesinfektion durch Zusatz von 0,5 v.H. Kupfersulfat oder 0,5 v.H. Sulfoliquid und die Ausmerzung infizierter Alttiere von der Zucht sowie die therapeutische Behandlung kranker Tiere.

SUMMARY

Among the trichomonads occurring in great numbers in the digestive apparatus of poultry, some have become known as excitants of diseases in pigeons, turkeys, and ducks, but their pathogenicity has not always been proved through tests made on animals with pure cultures. Among others, this is true in the case of trichomonads which may be observed in the case of small-pox, diphtheria and of colds with chickens; these may secondarily settle and increase as saprophytic parasites in dead tissues containing a large amount of protein. A specific infection of chickens with trichomonads, especially diphtheria caused by trichomonads, has not been proved so far.

Trichomonas columbae, however, has been definitely established in the disease which is the cause of trichomoniasis ("yellow button", flagellata-diphtheria) among squabs. It occurs as a violent fibrinous-diphtheroid inflammation of the cutaneous mucous membrane of the digestive apparatus particularly of the pharynx with the accumulation of fibrinous-purulent inflammatory substances in the accessory cavities of the head, in the lungs, air sacs, coelom, and pericardium. This disease is accompanied by a septic inflammation of the navel, frequently leading to extensive necrosis, peritonitis, and necrotic centers of the inner organs (liver, pancreas, lungs). The natural infection takes place through the feed and through the infection of wounds (inflammation of the navel); the sources of infection are adults which appear to be clinically healthy. The outbreak of the disease is favored through contributing factors such as unhygienic keeping and feeding, atmospheric conditions, polybacterial mixed infection and constitutional susceptibility. Measures for combating these contributing factors must be of a prophylactic nature; the disinfection of drinking water with 0.5 percent of copper sulphate and 0.5 percent of sulpho-liquid, and the removal of infected adult birds from breeding stock as well as therapeutic treatment of diseased animals are recommended.

AEGYPTIANELLOSIS OF POULTRY

By J. D. W. A. COLES, *Onderstepoort, South Africa*

In 1906 Balfour investigated a disease in fowls exposed for sale in the market place in Khartoum. In some birds he found spirochetes, in others an intracorpuscular hematozoon, and in still others, a mixture of the two. This mixture confused him and led to the name, *Spirochaeta granulosa penetrans*. He thought the disease was spirochetosis and that the intracellular forms were stages in the life cycle of the spirochete. Hindle later adopted this view and hypothesized a life history for *Spirochaeta anserina*, involving entrance of the spirochete into the erythrocyte and its subsequent multiplication there. Balfour once said he saw a spirochete penetrate an erythrocyte but later withdrew the statement; indeed, it is very doubtful whether the spirochete ever enters a red cell.

The attempts to identify this organism with a spirochete ended really with the work of Carpano in Egypt in 1928, when he described it as *Aegyptianella* and gave it its present name. A little later Carpano's work was confirmed by Curasson and Andrejesky in the French Sudan, and by Donatien and Lestoquard in Algeria. Jowett was the first to see the parasite at the Cape of Good Hope, but it was only in 1931 that the disease was observed again in South Africa. Apart from the countries already mentioned, Aegyptianellosis occurs in Tunis, Palestine, Greece, Jugoslavia, Albania, and Transcaucasia.

In nature the disease seems to be confined to the chicken, duck, and goose. Galli-Valerio inoculated a white rat with infected blood and apparently set up a fatal disease; this experiment does not seem to have been repeated.

ETIOLOGY

The disease is caused by the hematozoon, *Aegyptianella pullorum* (Balfour, 1906). For no apparently good reason, Dschunkowsky has suggested recently that the genus should be changed to *Balfouria*. He has created two species, *B. anserina* and *B. gallinarum*, but all the available evidence indicates that these are one and the same. It seems preferable to adhere to the name bestowed by Carpano.

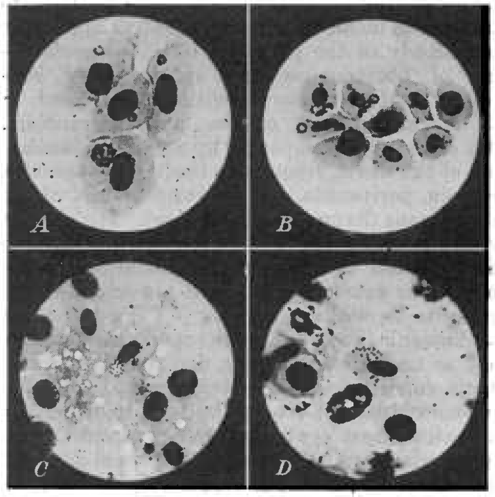

FIGURE 1.—*Aegyptianella pullorum: A*, Three infected erythrocytes and a half-developed schizont in a fourth (1,400 ×); *B*, ring forms—the small granules in the cytoplasm of the red cells are merozoites, which often tend to collect at the periphery of the cell (1,000 ×); *C*, a mature schizont (1,000 ×); *D*, a cell full of merozoites, after a schizont has broken up (1,000 ×). All smears stained with Giemsa.

The parasite is found in the red cells, where multiplication takes place by the formation of schizonts, each of which gives rise to about 16 to 24 merozoites. The merozoites leave the red cell, which presumably breaks down. No pigment is ever formed in the organisms. As is usual with hematozoa, the parasites are often fairly numerous in one or two organs, e.g., the lungs and spleen, but rare in the peripheral blood.

TRANSMISSION

Because *Argas persicus* was known to be the vector of spirochetosis, and since Balfour's bodies and spirochetes were associated in some vague way, it was only natural that the tick was held responsible for the presence of the intracellular granules or parasites. In 1909 Galli-Valerio apparently found Balfour's bodies in a fowl after specimens of *Argas persicus* from Tunis had fed on it. Then Balfour in 1911 seems to have infected a bird by inoculating it with the ground-up tissues of *Argas persicus*. The problem, however, remained obscure till 1933, when Bedford and Coles used pure strains of *Aegyptianella pullorum* and proved conclusively that *Argas persicus* was the vector. The following year Komarov confirmed these findings in Palestine.

So far transmission has been achieved only by the use of adult ticks. The tick feeds about once a month, for about half an hour at night. Twenty-six days after an infective meal, a tick transmitted the parasites to a chicken. An infected tick may remain a carrier for at least 162 days and can infect chickens at least at two successive meals. So far the larvae and nymphs of *A. persicus* and the adults of *A. moubata* and *A. perengueyi* have failed to transmit the disease, but the matter needs further investigation.

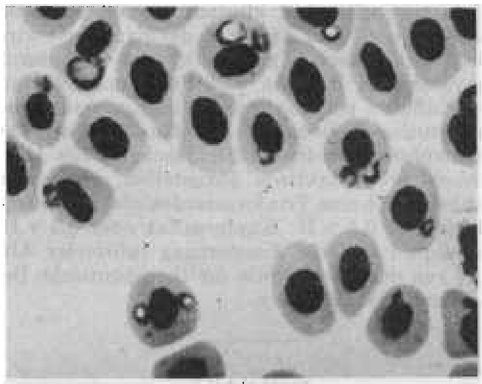

FIGURE 2.—*Plasmodium gallinaceum:* Trophozoites (2,000 ×). Stained with Giemsa.

SYMPTOMATOLOGY

The incubation period after exposure to an infected tick is 12 to 15 days or more. Apart from transient anemia, symptoms have not been noticed in older chickens and adult fowls in the laboratory, and ducks have been killed only after the intracerebral inoculation of the parasites. There is no doubt whatsoever that good housing and good food generally preclude the possibility of serious symptoms.

The parasites may be found in blood smears only on one or two days; on the other hand, they may be observed daily for two months or more.

The most severe symptoms seen in South Africa were in chicks infected naturally during the first few days of life. They showed loss of appetite, dejection, a green diarrhea, and occasionally icterus, which could be noticed in the conjunctiva, the iris, and even in the ring around the eye. Death occurred in a day or two. Older fowls show the same symptoms but usually in a milder form, and there may be fever. The feces may be greenish yellow in color and very suggestive of fowl typhoid. Anemia and icterus may be noted.

Jaundice is easily observed in the eye of the duck and gives the shank and foot a lemon-yellow color, if the skin is light.

Under field conditions adult chickens and ducks and geese undoubtedly succumb sometimes to Aegyptianellosis. Chronic cases also occur, the issue apparently depending on the standard of hygiene and nutrition.

In ducks and geese Aegyptianellosis is often associated with paralysis, especially of the legs. The neck may be twisted or be limp. The duck may thrust itself forward by flapping its wings.

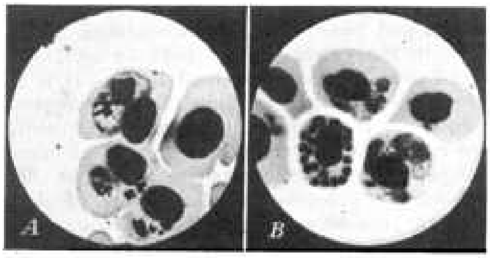

FIGURE 3.—*Plasmodium gallinaceum: A*, Top erythrocyte contains a microgametocyte with pale pinkish-blue cytoplasm and a large red nucleus—pigment granules are shown as dark spots to the left of the parasite's nucleus; *B*, nucleus of an erythrocyte surrounded by merozoites (2,000 ×). Stained with Giemsa.

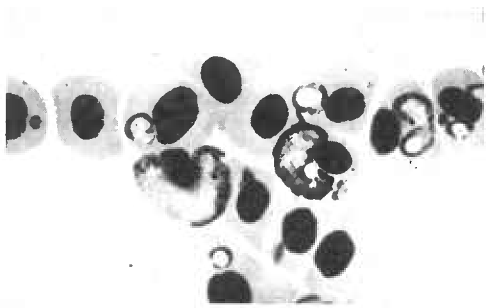

FIGURE 4.—*Plasmodium gallinaceum:* Lower erythrocyte to the left has no visible cytoplasm but contains a kidney-shaped blue macrogametocyte. To the right of this cell is a young purple schizont, just beginning to show the granules that will be merozoites. The other ring-shaped parasites are trophozoites (2,000 ×). Stained with Giemsa.

This paralysis, however, may occur in the absence of *A. pullorum* but in the presence of *Argas persicus*, and it is thought that it is not the result in any way of Aegyptianellosis. The paralysis is apparently due to infestation by certain strains of *Argas*, and it does not always abate when the ticks are removed. Ducks and geese under natural conditions usually succumb to the paralysis after 4 or 5 days but also after weeks. Each of two ducks was exposed for one night in a glass box to 35 starved adult *A. persicus* obtained from a duck house where numerous cases of duck paralysis occurred. All ticks were collected the following day; most of them had fed. One duck became suddenly paralyzed in the legs 6½ days later, and the other went down after 7 days. One case was killed for experiments and one recovered gradually within a week. The wings could be flapped, the tails waggled, and defecation was normal. The necks were not affected. At no time was *Aegyptianella pullorum* found in the blood.

PATHOLOGY

Young chicks show anemia and icterus, which may be very marked. There is atony of the crop and intestinal catarrh, the bowels being full of green slimy material. The liver is enlarged and yellowish. The spleen is greatly swollen. The kidneys have a pronounced yellowish-green color.

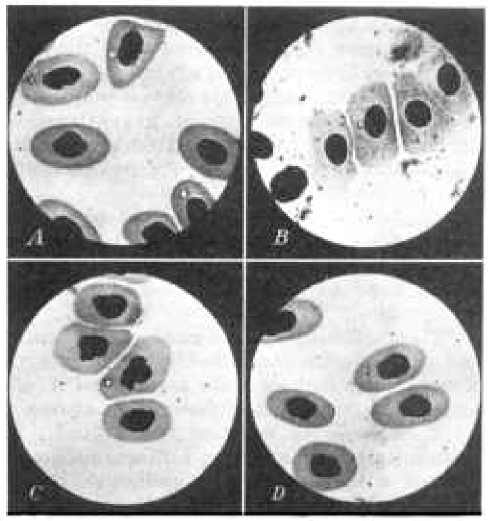

FIGURE 5.—New intra-erythrocytic protozoan of the fowl (1,400 ×): *C*, largest so far seen; *D*, possibly undergoing binary fission. All smears stained with Giemsa.

The picture is thus analogous to acute redwater in cattle.

Adult chickens, ducks, and geese exhibit anemia and possibly icterus. Enlargement of the spleen is common, and the organ may be purple and three or four times its normal size. There are swelling and degeneration of the liver and kidneys. The liver may be vivid green in color. Intestinal catarrh is common. The only two cases of intestinal volvulus ever seen at Onderstepoort were in fowls suffering from Aegyptianellosis. Sometimes there are no conspicuous lesions in adult birds.

DIAGNOSIS

This depends on finding the parasites which, in mild cases, may appear in the peripheral blood for only a day or two. The value of smears from the lungs, spleen, and other organs should be remembered.

Differential diagnosis

1. Spirochetosis. Find *Spirochaeta anserina.* Since the vector is common to both diseases, *Aegyptianella pullorum* may be preceded or accompanied by *S. anserina.* The spirochete generally has an incubation period of only a week; hence, Balfour saw the spirochetes first and referred to *A. pullorum* as the "after phase." Atoxyl and neosalvarsan will kill *S. anserina* but not *A. pullorum.* There is no cross immunity between the two diseases.

2. Erythroleucosis. Because of the anemia, icterus, and tumor splenis, this disease is often confused with Aegyptianellosis. There are, of course, no parasites. Mitotic figures in the blood stream suggest erythroleucosis, and the diagnosis should be confirmed by examining the liver, spleen, and bone marrow histologically.

3. Fowl typhoid. The dullness, greenish-yellow diarrhea, and fever lead to difficulties. *Salmonella gallinarum* can be isolated from the spleen and liver on brilliant green agar.

4. Leucocytozoosis. This disease may be confused with a chronic case of Aegyptianellosis. The leucocytozoa are transmitted by *Simulium* spp. and are large globular parasites inhabiting immature erythrocytes.

5. Hepatitis. Acute parenchymatous hepatitis is not uncommon in fowls and may be associated with jaundice. No blood parasites are present, and the liver should be subjected to histological examination.

6. Plasmodiosis. This disease affects fowls in the East, in Ceylon and Indo-China. It is carried by mosquitoes such as *Aëdes aegypti* and *A. albopictus.* The only way to differentiate between the two diseases is to examine blood films. The trophozoites of *Plasmodium gallinaceum* may be confused with *Aegyptianella pullorum,* but the latter parasite is not characterized by the presence of pigmented schizonts or gametocytes. Figures 1, 2, 3, and 4 reveal the differences very clearly. All these smears were stained with Giemsa.

7. A new intra-erythrocytic protozoal infection of the fowl (fig. 5). This occurs in South Africa and the United States of America, in New York and Pennsylvania. It is associated with anemia. The parasites are rounded and small, being 0.5μ to 1.5μ in size, and averaging 1μ. Multiplication appears to be by binary fission. There is usually only one parasite, and apparently never more than two, in a red cell. The organism is generally midway between the nucleus and the periphery. Nothing further is known about this parasite, except that it can occur, e.g., in New York, where *Argas* is presumably absent.

8. A fowl disease in Ceylon. Crawford has described this condition in a personal communication to the author. The parasites which inhabit the erythrocytes are morphologically indistinguishable, as far as can be judged at present, from *A. pullorum.* The inoculation of blood leads to infection in the fowl after about 13 days. Fowls indigenous to Ceylon do not seem to develop clinical symptoms, but imported birds show anemia, dullness, greenish diarrhea, and not infrequently slight swelling or puffiness of the head. Most cases recover after a short indisposition, but some fowls develop very heavy infections and die after an acute illness of sometimes less than a day. At autopsy the carcase is usually anemic, the gall bladder full of green bile, and the kidneys pale or yellowish in color. Crawford adds two very important statements; he says there is no swelling of the spleen and that *Argas persicus* is absent in the vicinity of the disease. Perhaps this is a new species of *Aegyptianella.*

9. A disease of penguins. The author has found anemia and blood parasites resembling *A. pullorum* in the young jackass penguin on Dassen Island near the Cape of Good Hope. It is not known whether they produce clinical symptoms of disease. Blood smears of other penguin chicks showed marked anemia and numerous mononuclears and spirochetes (species unknown). The penguin nests harbor large numbers of *Argas talaje* var. *capensis,* and there is little doubt that this tick transmits both these blood parasites.

PROGNOSIS

The prognosis is most serious in very young chicks; 90 percent of those infected may die. With increasing age the prognosis becomes more favorable. Where fowls are housed well on the intensive system and given an excellent diet, the disease runs a very mild course.

IMMUNITY

There is a state of premunition. Splenectomy leads to reinvasion of the blood by parasites after 10 days, but this is of short duration and not attended by fatal consequences.

TREATMENT AND PROPHYLAXIS

No remedy is known. Efficacious drugs have been described, but the laboratory experiments involved so few infected fowls that no definite conclusions can be deduced from them. As already mentioned, there is an extremely marked tendency to spontaneous recovery in properly housed experimental birds. As a prophylactic measure *Argas persicus* should be eradicated.

SUMMARY

Aegyptianellosis, which seems to be confined to chickens, ducks, and geese, is caused by the hematozoon, *Aegyptianella pullorum.* It is transmitted by the tick, *Argas persicus.* An infected tick may remain a carrier at least 162 days. The incubation period after exposure to an infected tick is 12 to 15 days or more.

The most severe symptoms seen in South America were in chicks infected naturally during the first few days of life. They showed loss of appetite, dejection, a green diarrhea, and occasionally icterus, which could be noticed in the conjunctiva, the iris, and even in the ring around

the eye. Death occurred in a day or two. Older fowls show the same symptoms but usually in a milder form, and there may be fever. The feces may be greenish yellow and very suggestive of fowl typhoid. Anemia and icterus may be noted. Jaundice is easily observed in the eye of the duck and gives the shank and foot a lemon-yellow color, if the skin is light.

In ducks and geese Aegyptianellosis is often associated with paralysis, especially of the legs. This paralysis, although apparently due to infestation with certain strains of *Argas*, may not be the result of *Aegyptianella pullorum.*

On post-mortem examination, a bird affected with Aegyptianellosis is found to have a swollen liver and spleen. In young chicks, these organs are yellowish or yellowish green. In adult birds, the spleen may be purple and the liver vivid green.

FACTORS IN THE RESISTANCE OF CHICKENS TO PARASITIC WORMS

By JAMES E. ACKERT, *Professor of Zoology, Agricultural Experiment Station; Parasitologist and Dean of the Division of Graduate Study, Kansas State College of Agriculture and Applied Science, Manhattan, Kansas, U. S. A.*

Experimental results obtained during the last decade leave no doubt that the resistant fowl is of major importance in the poultry industry. Without a constitution that will enable the fowl to resist the ravages of invading organisms, profitable production fails. Prominent among the invaders of the fowl population are the parasitic helminths: roundworms and tapeworms. The resistance of chickens to such parasites, especially to the roundworm *Ascaridia lineata* (Schneider), may be due to a number of factors, some of which are presented.

RESISTANCE AFFECTED BY DIETARY SUPPLEMENTS

Animal and plant proteins versus plant proteins

The unusually high incidence (49 percent) of the large roundworms *Ascaridia lineata* (Schneider) in 1,000 farm chickens in the vicinity of Manhattan, Kansas (Ackert, 1927), together with the frequent summer penning that precluded free insect ingestion, led to experiments by Ackert and Beach (1933) to test animal proteins as a factor in the resistance of chickens to this intestinal nematode. Three groups of Single-Comb White Leghorn chickens 4 days old were placed on the following diets: Group 1, on a basal cereal ration adequate for vitamins and minerals supplemented by meat meal and by skim milk ad libitum; group 2, on the same diet except that skim milk was omitted; and group 3, on a plant ration identical with that of group 2 except that peanut meal was substituted for meat meal in a volume equal to the amount of crude proteins in the meat meal. All groups were given water.

At 7 weeks of age each chicken was given approximately 500 embryonated eggs of the nematode. Three weeks later the chickens of all groups were killed and the worms isolated, counted, and measured.

The results of the experiments, involving 140 chickens, showed that the chickens of group 1 (fed cereals, meat, and milk) were the most resistant to the *A. lineata*, as they had significantly fewer and shorter nematodes than did either of the other groups. In addition, this group made the most rapid gains in weight. No constant differences in numbers of nematodes occurred between groups 2 and 3, but group 2 (fed cereals and meat) gave evidence of being more resistant to the growth of the *A. lineata* than did group 3 (fed cereals and peanuts).

The results indicate that the inclusion of skim milk and meat meal as supplements to a cereal basal ration increased the resistance and the growth rates of the chickens to the nematode *A. lineata*, but that the plant diet produced the slowest growth and the least resistance in the chickens to the nematodes. These results are attributed in part to the wider range of amino acids made available from the diets of groups 1 and 2, to the restricted range of amino acids, and to the slower digestibility of the plant diet of the chickens in group 3.

From these considerations it appears that milk and meat are important dietary supplements in the development of resistance to *A. lineata* and that a diet wholly of plant origin is not conducive to the production of either resistant or rapidly growing chickens.

Vitamins

The importance of certain vitamins in host resistance is now generally recognized so that only brief references are made to these dietary supplements. Work begun by Ackert, McIlvaine, and Crawford in 1927 and completed in 1931 showed conclusively that vitamin A as supplied in cod-liver oil is a potent factor in the resistance of chickens to the viability and growth of the fowl nematode *Ascaridia lineata.*

The vitamin B-complex as supplied in baker's yeast was shown in 1926 by Zimmerman, Vincent, and Ackert to be a factor in fowls' resistance to this nematode. Further work by Ackert and Nolf (1931) showed that lack of vitamin B-complex definitely favored parasitism, as significantly more worms remained in the vitamin-deficient chickens than in the control birds of the same age.

In four experiments with 150 chickens, vitamin D, as supplied by a mercury-vapor quartz lamp or by aerated cod-liver oil, did not affect the parasitism directly as there were no constant differences in the numbers or sizes of the worms in the experimental and the control birds. There was evidence, however, that the effects of parasitism were more marked in the vitamin D deficient chickens than in the controls (Ackert and Spindler, 1929).

RESISTANCE AFFECTED BY BREEDS OF FOWLS

As breeds of chickens differ considerably in constitution, size, and behavior, it appeared that they might differ in their resistance to the large roundworm *Ascaridia lineata*. The experiments by Ackert, Eisenbrandt, Wilmoth, Glading, and Pratt (1935) were facilitated by the opportunity to obtain from a commercial hatchery day-old chicks of four breeds and two varieties of a fifth breed at one time. All chickens under comparison were kept on the same adequate ration and were given the same numbers of embryonated eggs of the nematode *A. lineata*. The experiments, which extended over a period of 2 years and included a total of 1,351 chickens, gave results which showed that some of the breeds were significantly more resistant to the nematode than were other breeds. The criteria for judging the resistance were the average number and length of the *A. lineata* from each group of chickens under comparison.

Most resistant to the parasites were the relatively heavy breeds and varieties—Rhode Island Reds, White Plymouth Rocks, and Barred Plymouth Rocks. The most susceptible were the White Leghorns and White Minorcas. A strain of heavy White Minorcas proved to be more resistant to the *A. lineata* than a lighter strain of the same breed with different genetic constitution. Factors in the differences in resistance appear to include greater utilization of nervous energy by the most susceptible breed, the possible differences in strains within a breed, and the normality or tolerance of the host breeds.

AGE RESISTANCE

That age may be an important factor in the resistance of chickens to this nematode was found by Ackert and Herrick (1928), who discovered that heavy infestations of this nematode had severe effects on chickens 1 month of age but almost no effect on chickens 3 to 4 months of age. Further experiments showed that if growing chickens are kept free from these ascarids until they are 2½ months of age, chickens on an adequate diet may then swallow the infective eggs of this parasite without being noticeably harmed. These findings have since been confirmed by poultrymen in Kansas and many other States. By rearing their chicks on screens or on clean ground not previously frequented by adult chickens, they have raised flock after flock of broilers and other fowls almost free from attacks by the roundworm *Ascaridia lineata* (= *A. galli*).

What appears to be the first record of age resistance of chickens to tapeworms was made by Ackert and Reid (1937), who found that chickens 2½ to 5 months of age were significantly more resistant to the viability and growth of the fowl cestode *Raillietina cesticillus* than were younger fowls 1 to 2 months of age from the same flock.

FOOD OF THE NEMATODE

As an aid in studying the nature of the age resistance of growing chickens to the nematode *Ascaridia lineata*, experiments were run by Ackert and Whitlock (1935) and Ackert and Freeman (1936) to ascertain whether these roundworms feed on the intestinal epithelium or on the host ingesta.

In carrying out the experiments, chickens of the same age and breed were parasitized with the same numbers of infective eggs of the parasite. After allowing 1 week for the young worms to hatch and become established, the parasitized chickens were divided into two lots: The experimentals to be nourished only by water per os and intramuscular injections of glucose solution; the other group to receive water and the regular ration by mouth. The chickens under comparison were killed at the same time and the worms isolated, counted, and measured. The results of this series of experiments, which extended over a period of 2 years, showed that the worms in the injected chickens failed to grow, whereas those in the regularly fed chickens made normal growth. The conclusion is drawn that the large roundworm *A. lineata* of chickens normally feeds on host ingesta and not on the epithelial lining of the intestine.

SUMMARY

Experimental results obtained during the last decade leave no doubt that fowls resistant to parasitic worms are of major importance in the poultry industry. Without a constitution that will enable the fowl to resist the ravages of invading organisms, profitable production fails. Prominent among the invaders of the fowl population are the parasitic helminths: roundworms and tapeworms. The resistance of chickens to such parasites, especially to the roundworm *Ascaridia lineata* (Schneider), may be due to a number of factors, some of which are presented.

The inclusion of skim milk and meat meal as supplements to a cereal basal ration increased the resistance and the growth rates of the chickens to the nematode *A. lineata;* but a plant diet (in which peanut meal replaced meat meal as a supplement to the cereal basal ration) produced slower growth and significantly less resistance in the chickens to the nematodes. These results are attributed in part to the wider range of amino acids made available in the milk, meat, and cereal ration and to the restricted range of amino acids and the slower digestibility of the plant diet.

Other factors in the resistance of chickens to parasitism, as shown by experimental study, include vitamins A, B-complex, and D for protection against deleterious effects of roundworms.

Breeds of fowls are a factor in the resistance of chickens to the roundworm *A. lineata* (Schneider). The heavier breeds and varieties, namely, Rhode Island Reds, White Plymouth Rocks, and Barred Plymouth Rocks, were found to be more resistant than the lighter White Leghorns and White Minorcas. Resistant and susceptible strains of fowls may occur within a breed.

Age nearly up to maturity is a factor in the resistance of chickens to both roundworms and tapeworms, the older birds being more resistant than the younger ones.

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THE GAPEWORM AS A MENACE TO POULTRY PRODUCTION

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INTRODUCTION

The gapeworm, *Syngamus trachea*, has been responsible for a surprisingly high death rate among young poultry and game birds both in the United States and in Europe. Although this parasite is known to be present in many sections of the United States, there are no records of any serious outbreaks of gapeworm disease in this country within the last few years. On the other hand, the gapeworm has been frequently mentioned in the current literature as the cause of losses to poultry raisers in many parts of Europe. That such outbreaks have not occurred recently in the United States may be partly due to improved poultry-husbandry practices and to the fact that wild birds have apparently played an insignificant role in the spread of gapeworm disease in this country. However, it is the belief of many European parasitologists that wild birds play an important part in the perpetuation and spread of gapeworm disease in Europe. There is reason to suspect that the gapeworm may again become the serious pest in this country that it was a few years ago in the event that the starling, which has been recently introduced into the United States from Europe, becomes established in those areas where gapeworms occur. The starling has been reported by European parasitologists to be a carrier of gapeworms.

During the last 3 years the writer has devoted considerable time to a broad study of the biology of the poultry gapeworm and to a discovery of a satisfactory medicinal treatment for gapeworm disease. The results of these investigations are briefly presented in this paper.

SYMPTOMS OF GAPEWORM DISEASE

Gapeworms affect young birds primarily. The most typical symptoms are manifested by birds less than 8 weeks of age.

An extensive irritation of the mucous lining of the trachea is produced as a result of the presence of the blood-sucking gapeworms. Coughing is apparently the result of this irritation. Gaping quickly follows coughing and is usually accompanied by a quick jerk of the head forward or upward and an extension of the neck, thus indicating that the bird is not getting a sufficient amount of air. Sudden deaths are due primarily to suffocation caused by mechanical obstruction of the trachea by the rapidly growing worms and the rapid accumulation of secreted mucus.

Lesions or nodules are usually formed at the point of attachment of the male worms. Nodule formation is of frequent occurrence in the tracheae of infested turkeys but is rarely seen in infested chickens. These nodules may become so large as to interfere materially with normal breathing and may cause the death of the bird by asphyxiation. Such cases have been reported by Clapham (*2*) as occurring in pheasants in Europe.

Affected birds become weak and emaciated and spend much of their time huddled on the floor with the eyes closed and the head drawn back against the body. The head is regularly thrown forward or upward and the mouth is opened wide to draw in air, or the head may be given a convulsive shake in an attempt to loosen the obstruction in the windpipe so that normal breathing may be resumed.

The response of the young of the different types of poultry and game birds to gapeworm infestation is not uniform. Young turkey poults usually develop symptoms in about 7 or 8 days after infection, whereas young chickens usually do not show such symptoms until 10 to 14 days after infection. Similarly, the turkey poults begin to die from gapeworm infestations much sooner than young chickens. The characteristic symptoms of coughing and gaping have not been observed in the quail or the guinea fowl, whereas young pheasants apparently suffer from the disease to an extent comparable to that of young chickens. Older birds, unless heavily infested, usually show only mild symptoms, or none at all. Chickens more than 8 weeks of age infrequently harbor gapeworms and, therefore, rarely show symptoms of the disease. Guinea fowls have never been observed to develop symptoms even when heavily infested with gapeworms. Partly grown turkeys may harbor a few worms without showing any symptoms, but when heavily infested these birds may develop pronounced symptoms of coughing which are often accompanied by discharges of bloody mucus. Death among these birds may frequently occur within 2 to 3 weeks after infection. As a result of gapeworm infestation, older turkeys may develop a deep hoarse cough which may persist for several weeks, but the birds seldom die.

LIFE HISTORY

The eggs of the female gapeworm are deposited in the lumen of the trachea of the bird host. The eggs are coughed up, swallowed, and passed to the exterior in an unsegmented state in the droppings. Under favorable conditions of moisture and temperature, embryos develop inside these eggs within 9 to 14 days. When eggs containing larvae are swallowed by a susceptible host the larvae escape from the eggs, penetrate the wall of the intestinal tract, and reach the lungs unchanged as soon as 6 hours after the ingestion of the embryonated eggs. After molting twice in the lungs, the worms unite in pairs and reach the trachea in 7 to 8 days after the embryonated eggs have been ingested. Seven or eight additional days are required for the immature adults to reach egg-laying maturity.

RELATIVE EFFECTS OF GAPEWORMS ON YOUNG TURKEYS AND CHICKENS

Statements have been published that young turkeys commonly harbor gapeworms but suffer only rarely as a result of the presence of these worms. Young chickens have been reported as suffering severely from gapeworm infestation. In order to ascertain the relative effects of gapeworms on young turkeys and chickens, controlled experiments were carried out by the writer.

Approximately 225 young turkeys and as many young chickens about 10 days old were given approximately an equal number of embryonated eggs and larvae of *Syngamus trachea*. The results of these tests showed that young turkeys usually developed gapeworm symptoms earlier and began to die from gapeworm infestations sooner than young chickens. The mortality from gapeworm disease was greater in young turkeys than in young chickens. The number of pairs of worms developing and ultimately reaching the trachea was proportionately larger in the case of young turkeys and, furthermore, the inflammatory reaction in the trachea of the young turkeys was more severe than in chickens. Nodules were rarely observed in young chickens as a result of infestations with gapeworms, whereas numerous and sometimes large nodules occurred in young turkeys. These facts seem to indicate that under laboratory conditions, at least, young turkeys suffer more from gapeworm infestations than young chickens.

ROLE OF EARTHWORMS IN THE TRANSMISSION OF THE POULTRY GAPEWORM

The importance of earthworms in the transmission of the gapeworm lies chiefly in the ability of these annelids to serve as reservoirs for the infective gapeworm larvae during the winter months. Waite (*10*) demonstrated conclusively by controlled experiments that young chickens contracted gapeworms as a result of eating earthworms which had been taken from infested poultry runs in the fall and held over winter in clean soil. Kretzer (*3*) stated that young chickens showed heaviest gapeworm infestations during rainy seasons when the earthworms were most abundant on the surface of the soil.

Several species of earthworms have been shown to serve as carriers of infective gapeworm larvae. Clapham (*1*) demonstrated that *Helodrilus foetidus* was a much more suitable host for gapeworm larvae than *Lumbricus terrestris*. The writer has shown *Helodrilus caliginosus* to be a satisfactory carrier of gapeworm larvae. Infective gapeworm larvae have been reported by Taylor (*9*) to retain their infectivity for young chickens in earthworms for more than 3½ years.

Experimental evidence seems to indicate that the earthworm may play a slight role as a biological factor in the transmission of gapeworms. Morgan and Clapham (*5*) have shown that *Syngamus trachea*, taken from various wild and domestic birds, was more readily transferred to young chickens and with a greater degree of success if the earthworm was employed as an intermediate host in the transmission experiments. More recently, the writer (*11*) noted that young chickens, to which naturally and artificially infested earthworms had been fed, harbored a larger number of gapeworms than did those fed eggs containing unhatched infective larvae.

IMPORTANCE OF DOMESTIC AND WILD BIRDS IN TRANSMISSION OF GAPEWORMS

Ransom (*6*) concluded that the turkey and not the adult chicken was an important factor in the spread of gapeworm disease, and that infested turkeys and contaminated soil were the two chief factors responsible for the perpetuation of gapeworms from season to season. The results of certain experiments conducted by the writer support Ransom's conclusion and show that the turkey is capable of carrying this parasite for several months.

Nineteen turkeys from 30 to 124 days old were each fed approximately 1,500 embryonated eggs and larvae of *Syngamus trachea*. Twelve of these birds died within 2 to 3 weeks after infection as a result of gapeworm disease. Fecal examinations of the seven remaining birds, made at frequent intervals, showed that the infestations persisted for 88 to 224 days after infection. The bird that retained its infestation longest was 45 days old when infected on August 24, 1937, and did not lose its infestation until April 5, 1938. This experiment demonstrated that an infested turkey is capable of carrying gapeworms from one season to another.

The guinea fowl, like the turkey, may become infested with gapeworms at any time during its life and may remain infested as long as 3½ months. Ransom noted the presence of gapeworms among chickens on a number of farms on which he found no turkeys but on which he found guinea fowls mingling constantly with the chickens, but Ransom was unable to explain the source of the infestation.

The chicken probably plays only a minor role in the perpetuation of gapeworm disease, since adult birds rarely harbor gapeworms. If these birds are infected with gapeworms when very young and survive the acute stage of the disease, they may remain carriers of gapeworms for approximately 5 months.

Attempts to infect adult domestic pigeons and ducks with gapeworms were unsuccessful.

The role played by wild birds in the spread of gapeworm disease is still a moot question. Lewis (*4*) stated that starlings played a more important role in the spread of gapeworms than the turkey and that the latter served as a "bridging" between November and March when few or no chickens are raised. Rice (*7*) was convinced that the appearance of gapeworms in Ireland was closely correlated with the first appearance of young rooks in the poultry runs. Taylor (*8*) believed that wild birds played some part in the dissemination of gapeworms, but that they did not play so important a part as was believed by many investigators.

RESISTANCE OF DOMESTIC FOWLS TO PRIMARY AND SECONDARY GAPEWORM INFECTIONS

It is a well-known fact that adult chickens are seldom found to harbor gapeworms. However, Clapham (*1*) was able to infect with gapeworms 75 percent of the adult chickens that had been fed prior to infection a diet deficient in vitamin A and in minerals. Those birds that had received prior to infection a diet rich in these substances were resistant to infection with this parasite. It is, therefore, essential that the bird's diet include a considerable quantity of green material and minerals in order that it may better be able to ward off gapeworm infection.

The writer has found under experimental as well as under natural conditions that a single light gapeworm infection does not protect domestic fowls against a second infection. The domestic turkey and the guinea fowl, therefore, may continue to become reinfected under natural conditions as long as they remain on infested soil or with other gapeworm-infested birds.

TREATMENT

In 1938 the writer, in collaboration with Harwood, conducted a series of experiments for the purpose of discovering, if possible, a more effective remedy for the removal of gapeworms in poultry than had been recommended up to that time. These experiments involved the inhalation of various chemicals, in the form of dusts, by the affected birds.

Of a large number of chemicals tested, barium antimonyl tartrate was the only one that gave an efficacy sufficiently high to warrant more extensive experimentation. This drug was 98 to 99 percent effective against gapeworms in chickens in 10 tests. The drug caused increased gaping and coughing and produced a slightly depressed condition for a short time; otherwise, no symptoms of intoxication were observed.

SUMMARY

Syngamus trachea has been responsible for losses among young poultry, most deaths occurring in chickens and turkeys less than 8 weeks old. Death is caused by suffocation due to mechanical obstruction of the trachea by worms and accumulated mucus.

Gapeworm-infested birds usually develop symptoms of coughing and gaping. These symptoms are accompanied by a convulsive shake of the head forward in an attempt to expel the worms in the windpipe and to facilitate breathing. Affected birds become weak, emaciated, and frequently die from asphyxiation. The presence of the worms usually produce an extensive irritation of the mucous lining of the trachea that causes the birds to cough. Lesions or nodules are frequently formed at the point of attachment of the male

worms. Nodule formation is more frequently seen in infested turkeys than in infested chickens.

Birds become infested with gapeworms by infesting the embryonated eggs with the food or drink or by eating gapeworm-infested earthworms. Larvae reach the lungs as soon as 6 hours after infection, and pairs of immature adults have been found in the trachea 7 days after experimental infection of the host. Seven or eight additional days are required for the worms to reach egg-laying maturity.

Young infested turkeys usually develop symptoms of gapeworm infestation earlier and begin to die from this infestation sooner than young infested chickens. Four- to five-month-old infested turkeys have been observed to develop violent coughing spells, usually accompanied by discharges of bloody mucus. Such birds may die suddenly within 2 to 3 weeks after infection.

Earthworms are important agents in the perpetuation of gapeworm disease from season to season. Experiments have shown that gapeworms, which infest various wild as well as domestic birds, are more readily transferred to young chickens and with a greater degree of success through the ingestion of infested earthworms than through the administration of embryonated eggs and larvae from cultures. Earthworms have been reported to harbor viable infective larvae for at least 3½ years.

Guinea fowls and turkeys are susceptible to gapeworm infection throughout life. Infested turkeys may carry gapeworms for 7½ months, guinea fowls for 3½ months, and chickens for 5 months.

Experiments have shown that a single infection with gapeworms does not produce an immunity.

Barium antimonyl tartrate has been found, in laboratory tests, to be an effective remedy for the removal of gapeworms from chickens when this chemical is inhaled in the form of dust.

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SOME OBSERVATIONS ON INTESTINAL WORMS OF POLISH POULTRY

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During the investigations about 400 viscera of different birds, i.e., 200 hens, 100 geese, 55 ducks, 23 turkeys, 25 pigeons, and 1 wild duck, were dissected. The birds were bred in the district of Pulawy, a town situated on the Vistula banks in the center of Poland. The soil is diversified; there is little stagnant water and there are few forests. The investigations were undertaken in order to find out what are the most common parasites in the intestines of poultry, and whether these parasites may cause a more important disease.

Among geese the infestation was great, reaching 69 percent. The commonest parasite in geese is *Heterakis dispar*, being found in 45 birds. *Drepanidotaenia lanceolata* was found in 21 birds, *Weinlandia collaris* in 5, *Hymenolepis anatina* in 1, and *Amidostomum nodularis* in 1 bird. The intestines of geese and other birds were taken from the poultry slaughterhouse, where fat, well-fed birds were being killed. This is the reason why pathological lesions were very seldom met with, in spite of the frequent presence of parasites. In 55 ducks examined, worms were found in 25. Trematodes appertained to two species: *Echinoparyphium recurvatum* in 4 ducks and *Echino-*

stomum revolutum in 6. The following species of cestodes were found: *Hymenolepis tenuirostris* in 2 birds and *Weinlandia collaris* in 14. Two species of nematodes appeared: *Ascaridia galli* in 2 ducks and *Heterakis dispar* in 12. In the intestines of a wild duck were found *Polymorphus boschadis*, which caused a hemorrhagic inflammatory state. In 23 turkeys, 12 were infested, and *Heterakis gallinae* were found in 9 birds. In 3 young turkeys *Brachylaemus commutatus* was found. This fact deserves mention because of the young age of the turkeys (only several weeks) and because, until now, the appearance of *Brachylaemus* was limited to a climate warmer than that of Poland. In 25 dissected pigeons, only 5 had *Ascaridia columbae*.

Hens were the most important investigational material, their number being 200, or 50 percent of all the birds examined. Of these, 159 were infested. *Echinostomum revolutum* was found in 4 hens, *Amoebotaenia sphenoides* in 6, *Choanotaenia infundibulum* in 7, *Hymenolepis cantaniana* in 5, *H. carioca* in 2, *Raillietina tetragona* in 3, *R. echinobothrida* in 32, *R. cesticillus* in 42, *Ascaridia galli* in 17, *A. lineata* in 7, *Capillaria columbae* in 1, and *Heterakis gallinae* in 121. Because of the relatively great distribution of *Heterakis gallinae*, further investigations of this worm were made. In defining the species, the body length of the males was measured. A curve was drawn afterward with reference to the number of males found and their body size. A certain deviation was shown in the curve. This suggests the desirability of further investigation of the phenomenon. The body length of male worms was, on an average, 5.912 mm when the number of male and female specimens of *H. gallinae* did not exceed 10. When the dissection showed 100 to 200 specimens of *Heterakis gallinae*, the average body length of males reached 7.21 mm. The number of *Heterakis gallinae* found depends on either the degree of infection or the resistance of the birds themselves, as in some of the birds a greater number of worms developed than in others, under the same conditions of infestation.

The above-mentioned relation between the number of worms and body length shows, however, that a great number of parasites produce conditions favorable for growth, unless it is assumed that greater numbers of *Heterakis gallinae* occur in birds with weakened resistance.

SUMMARY

In an investigation of the helminthic intestinal fauna of poultry bred in central Poland, the following results were obtained:

Of 200 hens dissected, parasitic worms were found in the intestines of 159, i.e., *Echinostomum revolutum* in 4, *Amoebotaenia sphenoides* in 6, *Choanotaenia infundibulum* in 7, *Hymenolepis cantaniana* in 5, *H. carioca* in 2, *Raillietina tetragona* in 3, *R. echinobothrida* in 32, *R. cesticillus* in 42, *Ascaridia galli* in 17, *A. lineata* in 7, *Capillaria columbae* in 1, and *Heterakis gallinae* in 121.

Of 100 geese, 69 were infested with worms; 5 with *Weinlandia collaris*, 1 with *Hymenolepis anatina*, 21 with *Drepanidotaenia lanceolata*, 1 with *Amidostomum nodularis*, and 45 with *Heterakis dispar*.

Of 55 ducks dissected, 25 had intestinal worms: *Echinostomum revolutum* in 6, *Echinoparyphium recurvatum* in 4, *Hymenolepis tenuirostris* in 2, *Weinlandia collaris* in 14, *Ascaridia galli* in 2, *Heterakis dispar* in 12, and *Polymorphus boschadis* in 1.

Of 23 turkeys, 12 were infested: 3 with *Brachylaemus commutatus* and 9 with *Heterakis gallinae*.

Of 25 pigeons, only 5 were infested, all with *Ascaridia columbae*.

An investigation also was made to determine the relation between the number and the length of the parasites. In measurements of 112 males of *Heterakis gallinae* from all hens having not more than 10 *H. gallinae*, the length of the male was found to be 5.912 mm on an average. Of 226 males of *H. gallinae* from all hens having from 100 to 200 specimens of these worms, the average length was 7.21 mm. It appears therefore, that increasing number of *H. gallinae* in a host increases the length of this parasite. The number as well as the length of a parasite seems to result, at least partially, from the supply of food furnished to the parasite by the host.

INCIDENCE OF SALMONELLA TYPES IN FOWLS IN THE UNITED STATES[1]

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It is the purpose of this paper to deal, not with the well-known types of *Salmonella* that are largely restricted in their host relationships to the avian species, but with the large group of serologically related bacilli that parasitize all species of domestic animals and that are commonly associated with food poisoning in man. It is this group of bacilli whose exact identification has caused so much difficulty in the past and of whose pathogenicity so little is known.

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the director.

Many of the types were first recognized in food poisoning in man although the accumulated evidence unmistakably brands them as being primarily of animal origin. That they constitute a serious problem for the poultry pathologist will be evident from the material submitted.

In approaching any discussion of paratyphoid bacilli, it must be recognized that there is a striking lack of uniformity of opinion concerning the classification of the group. Many workers prefer the older classifications that are based largely on biochemical methods and in which a small number of species is recognized. Although it is admitted that the older classifications have the virtues of simplicity and ease of application, it must be acknowledged that they do not yield the exact information supplied by antigenic analysis as exemplified in the Kauffmann-White schema. It is true that antigenic analysis not only is time consuming but also divides the genus into a large number of serological types. Unless it can be demonstrated that these types are constant and that they are epidemiologically significant, their identification is not justified.

Bridges and Scott (1931) summarized their opinion of antigenic analysis thus: "The interest taken in the *Salmonella* group during recent years has resulted in the definition of many antigenic types, the status of which is as clearly independent as that of the commoner types associated with the enteric fevers and with acute gastro-enteritis." This view well expresses the opinion of the large majority of workers who have attempted to classify paratyphoid bacilli by the newer methods. When the phase variation of Andrewes (1922), the heat-stable and heat-labile receptors of Weil and Felix (1920), and the degeneration to the rough variants of Arkwright (1921) are considered, there is no doubt that the serological types are permanent and vary only within the narrow limits of these three phenomena. Through the use of the Kauffmann-White classification, one worker is able to confirm the results of another and organisms can be identified with certainty. It is a tribute to the Kauffmann-White schema that in our study of approximately 400 cultures of paratyphoid bacilli isolated from domestic animals in the United States, only five cultures did not belong to one of the known types. These five cultures represented four serological types whose antigenic relationships were determined, so that they are now recognized as distinct entities. It is highly improbable that this could have been accomplished by the use of the older methods.

That the types delineated by antigenic analysis are epidemiologically significant is rapidly being established. The recent work of Clancy and Jungherr (1938) demonstrates the value of the sero-typing of *Salmonella* cultures. The importance of careful typing is also apparent from our own work. In some instances it has been possible to demonstrate that fowls of diverse origin brought together into one flock were infected before assembly. One flock of poults that consisted of lots from three hatcheries harbored three *Salmonella* types. Poults purchased from each hatchery yielded a distinct type. In other instances it was possible to trace the introduction of infection from one flock to another through typing the bacilli. Through thorough examination of serological and biochemical characteristics, it was possible to distinguish types within a single bacterial species and to prove that these types were epidemiologically significant. In the face of this evidence the importance and value of antigenic analysis cannot be doubted.

Within the *Salmonella* group are certain species that are particularly adapted to specific hosts, the so-called primary *Salmonella* types. On the other hand, there are a large number of species that have no host specificity but apparently parasitize any host equally well. The importance of fowls as a reservoir for the second group, the so-called food-poisoning bacilli, can hardly be overestimated. Although these organisms are found occasionally in cattle, horses, sheep, and dogs in the United States, they are repeatedly isolated from fowls. It is important, therefore, that the identity of the bacilli affecting fowls be established and the comparative incidence of the different types be determined. In order to accomplish this, we have identified all the cultures of avian origin that we could obtain. Some of these were our own isolations, but most of them were obtained through the courtesy of other workers.

During a period of 4 years we have obtained and classified 223 cultures of *Salmonellas* derived from 100 outbreaks of disease. This figure does not include the many cultures of *S. pullorum* and *S. gallinarum* encountered, nor does it include the many cultures sent us as paratyphoid bacilli, which for one reason or another could not be included in the genus *Salmonella*. These paratyphoid-like or paracolon strains are in themselves a perplexing problem. They cannot be included in the paratyphoid group on account of their aberrant biochemical characters, and only rarely do they have more than a very slight antigenic relationship to true *Salmonella* strains. They are often found in animal disease and in food poisoning of man, and their connection with these conditions is worthy of additional study.

The distribution of the *Salmonella* types in fowls is given in table 1. The serological types are listed in the order of the frequency of their occurrence. Both the number of outbreaks and the number of cultures of each type studied are given for each species of bird. A total of 16 serological types is included in the table. As would be expected, the ubiquitous *S. typhimurium* (*S. aertrycke*) was found more frequently than all the other types combined. This organism was found in 62 percent of the outbreaks and composed 79 percent of the cultures studied. Conspicuous by its absence is the *Gärtner* group.

No cultures of *S. enteritidis* were encountered in the study. This is surprising since *S. enteritidis* is a widely distributed species and one of its variants (*S. enteritidis* var. *essen*) seems particularly adapted to ducks. Through the work of Hohn and Herrmann (1935), Jansen (1935), Lerche (1937), and others it is well known that *S. enteritidis* occurs frequently in fowls in Europe. Although the organism is known to occur rather commonly in rodents in the United States, we have not encountered it in outbreaks of disease in fowls.

Although *S. typhi-murium* was responsible for most of the outbreaks and occurred in approximately the expected incidence, the less well-known, sporadically occurring types were found in more than one-third of the cases. Such a high incidence for the rarer types is unusual. They seem to occupy the place usually held by *S. enteritidis*. Among the rarer types, *anatum*, *newington*, *senftenberg*, *derby*, and *newport* occurred most frequently. The remainder were found in only one or two outbreaks. These independent types, when they become established, cause a mortality as great as does *S. typhi-murium*. They are, therefore, a cause for no little concern.

Earlier in the paper the importance of serological types in the epidemiology of the infections was mentioned. This subject needs some elaboration. When one encounters an infection due to one of the rarer *Salmonella* types, the detection of carriers of that type is more or less conclusive evidence that these carriers were responsible for the disease. On the contrary, the detection of carriers of *S. typhi-murium* on premises where the infection occurred may leave one in some doubt as to the significance of those carriers. This lack of finality is due to the widespread distribution and frequent occurrence of the bacillus. It is obvious that any method of distinguishing different strains of the organism would be most useful. This can be done with a certain degree of success. We have found, for instance, that the well-known *S. typhi-murium* infection of pigeons is caused by a variant type that lacks one of the heat-stable antigens of typical strains. These variants can be further subdivided by a careful study of their biochemical characteristics and thus different strains may be distinguished. Serological differentiation of subtypes in *S. typhi-murium* applies not only to the variants from pigeons but also to other cultures. Christensen (1937) demonstrated that a second heat-stable antigen is present in some cultures and absent in others. This finding also is of epidemiological significance since all the cultures from a single outbreak are alike in containing or lacking this antigen. Thus by careful examination of the somatic antigens and the biochemical characteristics, it is possible to divide a single bacterial species into a number of epidemiological types.

In conclusion, it may be mentioned that most of the types found in fowls produce disease in man. It is probable that, under favorable conditions, all of them may attack human beings. A number of *Salmonellas* are transmitted through the egg. Infected eggs are not only dangerous to man but are also one of the sources of infection in fowls. If paratyphoid infection of fowls becomes more prevalent, the poultry pathologist

TABLE 1.—*Distribution of Salmonella types in fowls*

Type of *Salmonella*	Chickens		Turkeys		Ducks		Pigeons		Pheasants		Quail		Canaries		Total	
	Outbreaks	Cultures	Outbreaks	Cultures	Outbreaks	Cultures	Outbreaks	Cultures	Outbreaks	Cultures	Outbreaks	Cultures	Outbreaks	Cultures	Outbreaks	Cultures
	Numbers															
Typhi-murium	20	34	14	60	3	18	22	60	...	...	...	...	3	4	62	176
Anatum	2	4	2	2	1	2	...	...	...	...	...	...	...	...	5	8
Newington	2	2	1	3	1	2	...	...	...	...	...	...	...	...	4	7
Senftenberg	2	2	2	3	...	...	...	...	...	...	...	...	...	...	4	5
Derby	...	...	4	5	...	...	...	...	...	...	...	...	...	...	4	5
Bareilly	2	2	2	2	...	...	...	...	...	...	...	...	...	...	4	4
Newport	2	2	1	1	...	...	...	...	...	...	...	...	...	...	3	3
Oranienburg	1	1	...	...	...	...	...	...	...	...	1	1	...	...	2	2
Kentucky	1	1	...	...	...	...	...	...	1	1	...	...	...	...	2	2
Montevideo	1	1	1	1	...	...	...	...	...	...	...	...	...	...	2	2
Bredeney	...	...	2	2	...	...	...	...	...	...	...	...	...	...	2	2
Worthington	1	1	1	1	...	...	...	...	...	...	...	...	...	...	2	2
London	1	2	...	...	...	...	...	...	...	...	...	...	...	...	1	2
Muenchen	1	1	...	...	...	...	...	...	...	...	...	...	...	...	1	1
Minnesota	...	...	1	1	...	...	...	...	...	...	...	...	...	...	1	1
New brunswick	1	1	...	...	...	...	...	...	...	...	...	...	...	...	1	1
Total	37	54	31	81	5	22	22	60	1	1	1	1	3	4	100	223

may be forced to deal with the problem of its prevention.

SUMMARY

Several years of work on the *Salmonella* group has disclosed that fowls are the greatest reservoir of paratyphoid infection in the United States. Antigenic analysis was found to be the only satisfactory method of differentiating the numerous species studied. A total of 223 cultures was examined. Of these, 54 were isolated from chickens, 81 from turkeys, 22 from ducks, 60 from pigeons, 4 from canaries, and 1 each from a quail and a pheasant. The following distribution of types was found: *S. typhi-murium*, 176; *S. anatum*, 8; *S. newington*, 7; *S. senftenberg*, 5; *S. derby*, 5; *S. bareilly*, 4; *S. newport*, 3; *S. oranienburg*, 2; *S. london*, 2; *S. kentucky*, 2; *S. montevideo*, 2; *S. bredeney*, 2; *S. worthington*, 2; *S. muenchen*, 1; *S. minnesota*, 1; *S. new brunswick*, 1. The very large proportion of *S. typhi-murium* strains and the complete absence of *S. enteritidis* strains are most notable. The various types are distinct serological entities and are epizoologically significant. Several methods of dividing the ubiquitous *S. typhi-murium* into epidemiologically significant types are described.

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SALMONELLAINFEKTIONEN BEIM GEFLÜGEL UND IHRE BEDEUTUNG FÜR DIE EPIDEMIOLOGIE DER SALMONELLABAKTERIEN

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Erst mit Aufteilung der Bakterien der *Salmonella*gruppe in verschiedene Bakterien-Typen kam eine absolute Klarheit in das Vorkommen von Keimen dieser Gruppe beim Geflügel. Wohl hatte man gewußt, daß Bakterien der *Salmonella*gruppe beim Geflügel vorhanden sind, aber lange sprach man sie als Paratyphus B an, auch bezeichnete man bestimmte Keime als dem Typhus ähnlich.

Im vergangenen Jahrzehnt sind nun beim Geflügel zahlreiche *Salmonella*bakterien nachgewiesen worden, und zwar

1) *Bact. pullorum*
2) *Bact. gallinarum*
3) *Bact. ent. Breslau*
4) *Bact. ent.* Gärtner var. *Essen*
5) *Bact. ent.* Gärtner Kiel
6) *Bact. suipestifer* Kunzendorf
7) *Bact.* Newport
8) *Bact.* Senftenberg
9) *S.* Oranienburg
10) *Bact. anatum*

Verschiedene Keime wurden nur gelegentlich gefunden, sind also Zufallsbefunde, die nichts mit Seuchengängen zu tun haben und die nicht als Erreger von Infektionskrankheiten des Geflügels angesehen werden können. Hierzu gehören

Bact. suipestifer Kunzendorf bei Hühnerküken (Cernaianu)
Bact. Newport und Senftenberg beim Huhn (Edwards)
Bact. Newport und *S.* Oranienburg bei jungen Wachteln (Graham, Edwards)
Bact. ent. Gärtner Kiel bei Hühnerküken und Huhn (Schönberg, Lütje)

Lütje sah einmal in einem 14 Tage alten Kükenbestande, der in einem Kälberstall untergebracht war, eine Infektion mit Gärtner-Kiel und es kam hier zu erheblichen Verlusten (200 Erkrankungen, 8 Todesfälle).

Bact. ent. Gärtner wurde auch gelegentlich bei Tauben gesehen (Lesbouyries, van Dorssen, Shirlaw und Ganapathy Iyer).

Mehrere Typen des *Salmonella*gruppe sind aber Erreger spezifischer Infektionskrankheiten des Geflügels und haben sich bestimmten Geflügelarten angepaßt. Sie sind alle Erreger von Jungtierkrankheiten, die in den ersten Lebenstagen oder Lebenswochen auftreten und sich in Erkrankungen des Darmes, der Lungen, der Gelenke äußern oder septischen Verlauf nehmen. Ältere Tiere erkranken nicht, infizieren sich aber. Beim Geflügel lokalisieren sich die Bakterien mit Vorliebe in den Geschlechtsorganen, und zwar beim weiblichen Tier im Eierstock oder auch Eileiter, beim männlichen Tier in den Hoden. Auch in Leber und Darm siedeln sie sich an. Nur bei Einwirkung schädigender Momente kommt es bei erwachsenen Tieren zu Allgemeinerkrankungen mit sichtbaren Symptomen und tödlichem Ausgang. Derartige Einflüsse sind: Transport, Hunger, Durst, Futterumstellung, andersartige

Krankheiten, Parasiten. Vom Eierstock aus kann die Infektion des Eies erfolgen; bei Infektionen des Darmes ist eine Streuung der Bakterien durch den Kot möglich.

Überblicken wir diese Infektionen durch Bakterien der *Salmonella*gruppe, beim Geflügel, so finden wir:

Bact. pullorum (Rettger) als Erreger der Kükenruhr. Vorkommend bei Hühnerküken, Perlhühnern, Puten (Johnson und Anderson) und selten auch einmal bei Enten (Lerche), Tauben (Lahaye) und Sperlingen. Infektionen sind in den Geflügelzuchten aller Länder bekannt. Wesentlich ist, daß Bakterienträger die *Pullorum*bakterien im Eierstock beherbergen oder mit den Darmentleerungen ausscheiden.

Bact. gallinarum ist der Erreger des sogenannten Hühnertyphus oder der Kleinschen Hühnerseuche. Serologisch übereinstimmend mit *Bact. pullorum.* Nach Untersuchungen verschiedener Autoren, besonders von Truche, Staub und Bauche und Kauffmann, ist es biochemisch abgrenzbar gegenüber *Bact. pullorum.* Dies wird jedoch von Manninger, Beck, Eber, Beaudette, Hadley, Hendrickson, Mulsow, May, Goddner, van Heelsbergen, Lerche, Rebrassier, Köser und anderen bestritten. Vorkommen bei Tauben, Hühnern, Perlhühnern, Puten, Pfauen. Auch bei Entenküken treten zuweilen seuchenhafte Verluste durch *Bact. gallinarum* auf (Eber).

Das *Bact. pullorum* kommt sehr häufig vor, ebenso ist das *Bact. gallinarum* in manchen Bezirken und Jahren sehr häufig. Eine Übertragung dieser Keime ist auch auf andere Tiere möglich, da sie auf dem Gehöft frei herumlaufen und mehr oder weniger starke Berührung haben. Trotzdem sind Infektionen bei Säugetieren so gut wie unbekannt.

Da beide Infektionserreger starke Neigung besitzen, sich im Eierstock des Geflügels zu lokalisieren, gehen sie nicht selten in das Ei über. Damit besteht die Möglichkeit, daß sie von Menschen durch den Eigenuß aufgenommen werden. Erkrankungen von Menschen durch *Pullorum*bakterien sind aber bisher niemals gesehen worden. Dagegen berichtet Reiner Müller über eine Lebensmittelschädigung, die nach dem Genuß von Kartoffelsalat, auftrat der mit Hühnereiern zubereitet war, Sowohl bei Patienten als auch im Salat fanden sich Keime, die von Kauffmann als eine vergärungsmäßige Variante des *Gallinarum*-Typus angesehen werden. Da ähnliche Erkrankungen sonst niemals beobachtet wurden, scheint nur ein *Gallinarum*bakterien ähnlicher Typ (Variante nach Kauffmann) vorgelegen zu haben.

Bact. enteritidis Breslau. Beim Geflügel häufig und von großer Bedeutung.

Taubeninfektionen wurden in fast allen Ländern der Welt festgestellt und eingehend beschrieben. Sie sind eine Jungtierkrankheit, die zu hohen Verlusten führt. Bei dem Infektionserreger handelt es sich um einen spezifischen Typ der Breslaubakterien, der im O-Antigen meist abweichend ist (Edwards; Fehlen des Faktors V), der häufig Wallbildung (Beck und Mayer) besitzt, der nach Hohn und Herrmann ammon-negativ ist und Maltose vergärt (Jungherr und Kingston). Es kommen jedoch bei Tauben auch andere Typen vor.

Tauben streuen infolge ihres Herumfliegens die Infektionserreger sehr stark (Schütt, Wütig, Gaede). Daher bietet sich für andere Tiere eine reiche Infektionsmöglichkeit. *Enteritis*-Breslaubakterien wurden auch bei wildlebenden Vögeln, wie Fink, Zeisig, Meise, Sperling wiederholt gesehen.

Inwieweit Taubenenzootien zur Übertragung auf Säugetiere führen, ist nicht ganz geklärt. Hoffmann und Edwards sahen eine spontane Übertragung der Breslaubakterien von Tauben auf Kaninchen, wir konnten sie beim Schaf feststellen. Vereinzelt ereigneten sich auch Erkrankungen von Menschen nach dem Genuß von Taubenfleisch (Meyer) und von Süßspeise, die aus Taubeneiern hergestellt wurde (Clarenburg und Dornickx).

Recht häufig sind auch Infektionen des Wassergeflügels mit Breslaubakterien. Vor allem werden sie bei Gänsen und Enten beobachtet. Nach Hohn und Herrmann sollen die beim Wassergeflügel auftretenden Breslaubakterienstämme meist rhamnosenegativ sein. Dies trifft aber nach meinen Feststellungen nicht zu. Die Breslaubakterien bewirken beim Wassergeflügel in der Regel Jungtierkrankheiten. Derartige Gänse- und Entenkükeninfektionen wurden oft beschrieben, und zwar von Weissgerber und Müller, Pfeiler, Burghoffer, Strozzi, Schaaf und anderen. Sonst sind die Tiere Träger und Ausscheider der Bakterien—Die Ansiedlung der Keime erfolgt in Eierstock, Leber und Darm. Bei gesunden Gänsen treffen wir daher Breslaubakterien verhältnismäßig oft im Kot. Bei ihren Untersuchungen fanden sie von Bornstedt und Fiedler in 2.9 prozent und Standfuß in 4 prozent der untersuchten Gänse, Wilken in 3,9 prozent, Hüsgen fand sie in 14 prozent der bakteriologisch untersuchten Gänse, Wundram und Schönberg in 24 prozent der in Berlin wegen Geflügelcholera beschlagnahmten Tiere.

Ähnlich liegen die Verhältnisse bei Enten (Scott, Gaiger und Davis, Hole, Jansen, Haffke, Schaaf, Lerche, Pallaske, Warrack und Dalling, Weber).

Das Wassergeflügel besitzt eine besondere Neigung zur Infektion mit Breslaubakterien und trägt zur Weiterverbreitung der Keime stark bei. Zuweilen wurde die Auffassung vertreten, daß Wassergeflügel sich hauptsächlich infiziert, weil es zu Tümpeln und Abwässern Zutritt hat. Wenn derartige Infektionsquellen auch zuzugeben sind, so ist doch zu beachten, daß Breslaubakterien sich speziell dem Wassergeflügel angepaßt haben und daß es unter ihm völlig gesund erscheinende Dauerausscheider gibt. So konnte ich bei 2 Gänsen die unverminderte Breslaubakterienausscheidung bisher über 29 Monate verfolgen. Der Nachweis der Keime gelang stets im Kote, nicht jedoch im Ei, vereinzelt auf den mit Kot beschmutzten Eiern. Solche Gänse sind eine Gefahr für ihre Umgebung. Die von mir erwähnten beiden Ausscheider wurden von uns ermittelt, nachdem Lebensmittelschädigungen aufgetreten waren. 100 Personen erkrankten nach dem Genuß von Fleisch eines gesund geschlachteten Rindes. In dem Rinderbestande fand daraufhin eine amtliche Untersuchung statt. Hierbei wurden weitere 4 infizierte Rinder (1 Bulle, 3 Kälber) ermittelt. Unsere Umgebungsuntersuchungen lehrten, daß außerdem 4 Gänse und 1 Ente Ausscheider waren und daß auch das Teichwasser Breslaubakterien enthielt. In diesem Bestande war das Wassergeflügel die Ursache der Rinderinfektion und so auch indirekt Veranlassung der Fleischvergiftung. Ähnliche Verhältnisse beobachtete ich in einem Entenbestande, dessen Eier zu Gesundheitsschädigungen geführt hatten. Hier waren Enten, Gänse, Schweine und Tauben sowie das Teichwasser infiziert. Auch in anderen Tierbeständen, in denen gelegentlich der bakteriologischen Fleischuntersuchung Breslaubakterien ermittelt wurden, konnten wir solche Streuungen feststellen. Diese Beobachtungen wurden in neuerer Zeit auch durch Stenert bestätigt, der bei einem notgeschlachteten Bullen Breslaubakterien fand und bei einer systematischen Untersuchung des gesamten Tierbestandes Breslaubakterien bei Gänsen, Enten, Kälbern, Jungbullen, Pferden und einem Schaf nachwies. Auch hier war die Infektionsquelle das Wassergeflügel.

Wassergeflügel kann also Breslaubakterien streuen und so zu erheblichen Verbreitung der Bakterien Veranlassung geben. Der Infektionsweg geht direkt über den Kot, in dem sich nach unseren Untersuchungen die Breslaubakterien bis zu 3 Jahren lebensfähig halten können. Zuweilen vermittelt auch das Wasser die Bakterien. Jedoch pflegt dies sich innerhalb von 30-36 Tagen selbst zu reinigen.

Die Infektion haftet nicht immer ohne weiteres. Vielmehr scheint eine besondere Prädisposition der übrigen Tiere erforderlich zu sein. Bei unseren Versuchen erkrankten mit den bereits erwähnten, Breslaubakterien ausscheidenden Gänsen zusammengehaltene Kaninchen nicht. Schweine, Schafe und Hühner wiesen nur vorübergehend die Erreger im Kot auf. Die Hühnereier blieben stets negativ. Das Wassergeflügel ist, wenn es infiziert ist, eine besondere Gefahr für den Menschen. Oft bewirkte der Genuß von Gänseleber, Gänsespickbrust und zuweilen auch Gänsebraten Gastro-Enteritis (Baars, Seligmann und Clauberg, Preßler, Kolbe, Meyer, Wundram und andere). In viel höherem Maße jedoch kam es während der vergangenen Jahre zu Schädigungen durch Enteneier, welche vom Eierstock aus infiziert oder mit bakterienhaltigem Kot besudelt waren. Zahlreiche Gruppenerkrankungen durch Enteneier oder durch Speisen, die mit ihnen hergestellt waren, beschrieben Scott, Willführ, Fromme und Bruns, Fromme, Müller, Schönberg, Kathe und Lerche, Mießner und Köser, Grebe und Graening, Sauer, Zeug, Wesselmann und andere. Die Zahl der Gruppenerkrankungen betrug vom Jahre 1932 bis 1935 in Deutschland insgesamt 86, die Zahl der Erkrankten 520, die Zahl der Todesfälle 15 (Goerttler). Abwehrmaßnahmen waren daher dringend erforderlich. Es ist aber nicht möglich, durch Blut- und Kotuntersuchungen infizierte Tiere mit Sicherheit zu erkennen (Warmer, Goerttler, Jansen). Daher blieb als einziges aussichtsreiches Mittel eine Kennzeichnung des Enteneies und eine Warnung des Publikums durch besondere Aushänge in den Geschäften, weil man nichtden Enteneigenuß völlig verbieten wollte. Zu den gleichen Maßnahmen griff auch Holland.

Breslaubakterien kommen auch bei Hühnervögeln vor. Bisher wurden jedoch nur einige Enzootien bei Hühnerküken (Doyle, Gaiger und Davies, Schalm) beobachtet. Bei erwachsenen Hühnern wurden sie stets nur als Zufallsbefunde festgestellt. Ebenso sind sie nur ganz vereinzelt einmal in Hühnereiern festgestellt worden. Für den Menschen bietet das Hühnerei keine Gefahr. Verlustreicher sind die Breslauinfektionen zuweilen auch bei Putenküken (Rettger, Lippay, László, Pfaff). Auch einige derartige Seuchengänge unter jungen Fasanen kamen vor (Altemeier, Lerche).

Erwähnen möchte ich nur kurz, daß Breslauinfektionen auch bei Möven, Kanarien, Papageien und sonstigen Vögeln der Zoologischen Gärten vorkommen. Eine Mittlerrolle scheinen hierbei die Mäuse spielen zu können (Schmidt).

Bact. enteritidis Gärtner. Als seuchenartige Krankheitsursache sind Gärtnerbakterien vor allem bei Enten bekannt (Jansen, Warrack und Dalling, Dunning, Pallaske). Untersuchungen von Hohn und Herrmann lehrten, daß es sich um einen besonderen Typ handelt, der serologisch mit Gärtner-Jena übereinstimmt, der aber durch sein Verhalten gegenüber Dulzit abweichend ist: Typ Gärtner-Essen. Er hat sich weitgehend der Ente angepaßt und kommt in vielen Ländern vor. Er kann ebenfalls durch das Ei zu Lebensmittelschädigungen führen.

Bact. anatum. Beschrieben als seuchenartige Entenkükenkrankheit von Rettger und Scoville. Sonst nur wenig bekannt. Einige Varietäten davon wurden vereinzelt bei Lebensmittelschädigungen in Deutschland beobachtet.

Die Darlegungen zeigen, daß Bakterien der *Salmonella*-Gruppe unter dem Haus- und Wildgeflügel stark verbreitet sind. Einige Typen gehen auch leicht auf andere Tiere über, sodaß Geflügel zu starkem Umsichgreifen der Infektion unter den übrigen Haustieren führen kann. Hierdurch, aber auch direkt durch Fleisch und Eier des Geflügels, ist der Mensch gefährdet. Daher ist die Forderung berechtigt, daß der *Salmonella*infektion in der Geflügelzucht ganz besondere Aufmerksmakeit geschenkt wird.

ZUSAMMENFASSUNG

In den vergangenen Jahrzehnten wurden aus der *Salmonella*gruppe beim Geflügel *B. pullorum,*

gallinarum, B. ent. Breslau, *B. ent.* Gärtner var. *Essen* und *Kiel, B. suipestifer,* Newport, Senftenberg, Oranienburg und anatum ermittelt. Als Erreger spezifischer, seuchenhafter Infektionskrankheiten fanden sich nur die vier zuerst genannten. Sie waren die Ursache von Jungtierkrankheiten, während ältere Tiere nur infolge schädigender Einflüsse erkranken und sonst die Bakterien in den Geschlechtsorganen oder im Darmtraktus beherbergen.

Bei Hühnervögeln kommen vor allem *Pullorum-* und *Gallinarum*infektionen vor. Eine Übertragung auf andere Tierarten wurde kaum beobachtet. Eine Erkrankung von Menschen wurde nur einmal durch *Gallinarum*bakterien von R. Müller beschrieben, wahrscheinlich waren aber die hierbei ermittelten Keime nicht mit dem echten *Gallinarum*bakterium identisch.

Wichtiger sind für den Menschen die Breslaubakterien. Sie führen zu schweren Seuchengängen bei Tauben und Wassergeflügel, während Hühnervögel selten erkranken.

Die Taubeninfektionen wurden in der Regel durch eine besondere Taubentype bewirkt. Durch Streuung der Krankheitserreger erfolgt Infektion von wildlebenden Vögeln, gelegentlich auch von anderen Haustieren. Menschenerkrankungen sind selten. Das Wassergeflügel (Gans, Ente) kann als Dauerausscheider die Breslaubakterien auf alle Haustiere vermitteln und bewirkt hierdurch menschliche Erkrankungen. Organe und Fleisch von Gänsen sowie Enteneier waren häufig die Ursache schwerer Lebensmittelschädigungen. Unter den Hühnervögeln finden sich im Gegensatz zum Wassergeflügel Dauerausscheider kaum. Das Hühnerei ist daher für den Genuß ungefährlich.

Das *Bact. ent.* Gärtner Essen nimmt beim Wassergeflügel eine ähnliche Stellung wie die Breslaubakterien ein, nur sind Übertragungen auf andere Tierarten selten.

Die starke Verbreitung der *Salmonella*bakterien und ihr starkes Streuen auch im übrigen Haustierbestande erfordern besondere Aufmerksamkeit des Tierarztes.

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SUMMARY

During past decades, the occurrence of *Bact. pullorum, Bact. gallinarum, Bact. ent.* Breslau, *Bact. ent.* Gärtner var. *Essen* and *Kiel, Bact. suipestifer*, Newport, Senftenberg, Oranienburg, and Anatum in the paratyphoid group were established with fowls. Only the first four of the above-named bacteria were found to be exciters of specific, epidemic, infectious diseases. They are the causes of diseases with young animals, whereas older animals become diseased only under unfavorable influences but carry the bacteria in the sexual organs or in the intestine.

Particularly infections with *Bact. pullorum* and *Bact. gallinarum* are observed in fowls. A transmission to other species of animals has hardly been established. An infection of humans with *Bact. gallinarum* has been described only once by R. Müller; it is believed, however, that the bacteria found in this instance were not identical with the true *Bact. gallinarum.*

Of greater importance for humans are *Bact. ent.* Breslau. They lead to serious epidemics in pigeons and water fowl, whereas fowls are seldom affected.

As a rule, the infection of pigeons is caused by a special pigeon type of bacteria. Due to the scattering of the pathogenic agents, wild birds and occasionally other domestic animals may become infected. Water fowl (geese, ducks) may transmit the *Bact. ent.* Breslau to all domestic animals through continuous excretion of the bacteria and the infection of humans may be caused in this manner. The organs and the flesh of geese, as well as ducks' eggs, were frequently found to have caused great harm to persons eating the same. Among the fowls, there are hardly any individuals with continuous excretion of bacteria as in the case of water fowl. Chickens' eggs are, therefore, harmless for consumption.

The importance of *Bact. ent.* Gärtner Essen with poultry is about the same as that of *Bact. ent.* Breslau, but transmission to other animals is seldom.

The widespread occurrence of the bacteria of the paratyphoid group and their further spread and transmission among other domestic animals require the particular attention of the veterinarian.

PRESENT STATUS OF PULLORUM DISEASE IN THE UNITED STATES[1]

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Pullorum disease is one of the oldest poultry maladies recognized in the United States. For at least 40 years the disease has been an economic problem to the poultry industry in this country. However, during the last 4 decades scientific contributions concerning the various aspects of the disease have laid the foundation for an effective and practical program for the control and eradication of this great poultry scourge.

SURVEY OF THE DISEASE

According to reports received from most of the States in this country, pullorum disease continues to be responsible for losses among young chicks, although during the last few years some reduction in chick mortality due to pullorum infection has been observed. This reduced mortality is in a large measure attributed to the increased interest manifested throughout this country in the control and eradication of the disease. Control and eradication efforts are being directed toward strategic points where the disease is most vulnerable.

Pullorum disease testing is being carried on in every State, 44 States having adopted either official or semiofficial control and eradication measures. Three testing methods are employed for the detection of carriers, but the whole-blood agglutination test and the tube agglutination test are the most extensively used. The former method is employed in those sections where the cost of operation of the tube method has been too great for the industry. Most of the States are recognizing one or more of the three official grades established for pullorum-tested flocks by the United States Department of Agriculture, under the National Poultry Improvement Plan. In most States the removal and disposal of reactors, as well as the cleaning and disinfection of premises after removal of reactors, are placed under the responsibility of the flock owner or hatcheryman. In a few instances these phases of the control and eradication operations are executed directly by the State disease-control agency. Eight States have reported special statutes pertaining to the control and eradication

[1] Contribution No. 329 of the Massachusetts Agricultural Experiment Station.

of pullorum disease. The average prevailing testing charge to the flock owner or hatcheryman is 3 cents per bird. In most States the charge is insufficient to support the cost of the testing program. In several States $25,000 to $30,000 is being expended annually for official pullorum disease control and eradication. Most of the States report that the official agency resorts to necropsies of reacting birds as a supplement to the test when necessary to establish a definite flock diagnosis. Official control of advertisements concerning the pullorum status of flocks is exercised in only a few States. Poultrymen or hatcherymen operating under the National Poultry Improvement Plan are subject to controlled advertising. Lists of tested flocks are published by 20 States.

INVESTIGATIONAL OBSERVATIONS

Pullorum disease investigations have paved the way for the development and operation of a successful program for the control and eradication of the disease. During the last 10 years researches have been followed to solve those problems that are directly related to the combat of the disease.

The complex problem of pullorum disease dissemination has been investigated. Research findings (*1, 2, 3*)[2] point out that the causative agent is most frequently spread from mature stock to mature stock or from parent to progeny by way of the egg. Individual birds may contract the disease without difficulty by eating freshly laid eggs produced by reacting birds. In the case of flocks in which birds develop the habit of egg eating, this knowledge is significant in preventing the dissemination of the infection. Efforts to prevent the eating of eggs laid on the dropping boards or the floor and the prompt removal of birds that have acquired the habit of egg eating should materially reduce the spread of the causative agent.

Pullorum-infected birds may eliminate the organism by way of the droppings, according to observations of several investigators (*3, 4*). However, spontaneous infections resulting from contaminated feces appear to be infrequent since feces from reacting birds, when force-fed to nonreacting birds, caused but a low incidence of infection. This statement may hold true only in cases in which acute infections do not exist. Among maturing and adult birds, pullorum infection that is feces-borne in origin presents an important practical control and eradication problem. Especially is this true in the application of proper sanitary measures for eradication of the disease. Investigations in progress have revealed that *Salmonella pullorum* may remain viable on a dry piece of cloth maintained in the laboratory for at least 5½ years. Although the pathogenicity at the end of this period may be questioned, as long as the organism is viable a potential pathogenic role still exists.

The behavior of *S. pullorum* in response to different environmental conditions may vary greatly (*5, 6, 7, 8*). Freshly isolated strains may exhibit characteristics that differ from those possessed by a type strain. Variants have been identified that exhibited one or more peculiar characteristics, such as atypical colonial and cellular morphology, auto-agglutination or settling in normal saline solution, maltose fermentation, and partial or complete loss of antigenicity and pathogenicity. The fact that variants occur among *S. pullorum* strains emphasizes the necessity for employing adequate and appropriate methods and materials in the isolation, identification, and maintenance of cultures. Strains that are used in the preparation of antigen employed for the agglutination test should be maintained under an environment that produces stability of all characteristics. This fact is recognized in the Standard Methods of Diagnosis for Pullorum Disease in Barnyard Fowl (*9*), which was adopted by the Conference of Official Research Workers in Animal Diseases of North America and by the United States Livestock Sanitary Association.

The macroscopic agglutination test, which is used for the detection of diseased carriers, has been investigated from the standpoint of increasing its efficiency and practicability. It is recognized that the whole-blood stained-antigen test when properly applied has certain advantages over the macroscopic tube-agglutination method. However, the manner in which the whole-blood method is being conducted does not yield results equal in efficiency to those obtained by the tube method. The efficiency and reliability of the former can be increased when a serological pipette is used to measure definite, constant quantities of whole blood and antigen. The various physicochemical factors that play a very important role in the accuracy of the test should be further investigated and the testing method modified accordingly. The whole-blood test as employed at present produces results that cannot be regarded as sufficiently reliable to meet the requirements established for such official grades as U. S. Pullorum Passed or U. S. Pullorum Clean.

It is becoming more apparent that the domestic chicken is not the only reservoir of pullorum infection. Recent reports (*8, 10, 11, 12, 13*) reveal that ducks and turkeys may readily contract the disease, and in the latter species the evidence suggests very strongly that the causative agent may be transmitted from parent stock to progeny by way of the egg. In many instances of pullorum disease in turkeys, the origin of the infection is traceable to infected chicks or incubators and brooders contaminated with *S. pullorum*. In infected turkey flocks the affected individuals may be detected by the macroscopic agglutination test. However, the elimination of the disease appears to be more difficult than in

[2] Italicized numerals in parentheses refer to Literature Cited, p. 282.

chickens because in some instances the agglutination reactions seem nonspecific and may or may not continue to persist on short-interval testing. *S. pullorum* has been recovered from turkeys whose sera possessed a titer as low or lower than 1:40. Although the macroscopic agglutination test may possess certain shortcomings, as a diagnostic agent for pullorum disease in turkeys its use should be encouraged in flocks of valuable breeding stock. Proper preventive and sanitary measures should be strictly observed in avoiding the spread or the introduction of infection.

CONTROL AND ERADICATION ACTIVITIES

Since 1914 the macroscopic agglutination test has been employed for the detection of pullorum infection among poultry flocks. In the control and eradication of the disease this test is the most valuable means at our disposal. However, its effectiveness is only as great as the efficiency of the methods employed and the competency of the person conducting the test. These facts were recognized by those persons who organized the Conference of Laboratory Workers in Pullorum Disease Eradication in 1928, for the purpose of improving and standardizing the technique employed in pullorum disease testing, as well as bringing about a greater uniformity of interpretation of results. The macroscopic agglutination test was regarded as representing only an integral part of a control and eradication program. Other fundamental disease-control and eradication measures were regarded as essential for an effective program. This conference was originally composed of the 6 New England States, but now includes 15 States and 1 Canadian Province, all of which are sponsoring an active testing program. The accomplishments of this conference have exerted a beneficial influence on the control and eradication of the disease in this country. Greater progress in the elimination of the disease may be anticipated through the organization of similar conferences in other sections.

Another progressive movement in the combat against pullorum disease in this country was the establishment of the National Poultry Improvement Plan (*14*). The primary objectives of the plan are to establish the poultry-breeding industry on as sound a basis as possible and to identify, authoritatively, poultry breeding stock, hatching eggs, and chicks with respect to quality by describing them in terms uniformly accepted in all parts of the country. In 1938, 42 States participated in the plan. The plan that is optional for State participation has brought about concerted action in pullorum disease control and eradication. According to a Federal report, in October 1938 there were 37 States cooperating in the pullorum disease phase of the plan. With a nationwide attack on pullorum disease through a national plan, it is hoped that the disease will be reduced eventually to a very low figure.

In the control and eradication of pullorum disease there are several measures that should be recognized. A brief discussion is given of some of the more important ones.

In order to determine the disease status of a group of individuals, all of them must be examined or tested. This statement applies to a flock of poultry that is to be tested for pullorum disease. It has been observed that if one or more infected birds remain in a flock, losses from the disease may result.

Annual testing is essential to determine whether or not the flock has become reinfected. In Massachusetts the testing results for the last 8 years reveal that approximately 3 percent of the nonreacting flocks became reinfected. In many instances the source of the infection was unknown. Furthermore, the majority of "breaks" occurred in flocks with a short nonreacting testing history.

The establishment of a pullorum-free flock by means of intensive retesting (testing at 4-week intervals) and the prompt removal of reactors has been found to be practical and successful in flocks whose breeding value warranted the expenditure for retesting. It has been observed that pullorum infection may be eliminated from a flock when it is subjected to a single test. In most flocks the elimination of infection has required three tests. The number of tests to be employed depends on the amount of infection present and on the condition and environment of the flock.

A flock should not be classified as positive for pullorum disease when only doubtful reactors are detected. In such instances, the agglutination test should be supplemented with necropsy of such reacting birds and a flock should be declared positive only when conclusive evidence of infection has been obtained. This type of follow-up diagnostic service is of great value to the poultryman whose flock has revealed only doubtful reactions after having been nonreacting for a number of successive years. Observations have shown that doubtful pullorum reactions may result from other specific or nonspecific infections. In such instances bacteriological examination would permit an accurate diagnosis of the disease or diseases present.

The spread of pullorum infection throughout this country can be attributed in a great measure to the practice of custom and commercial hatching and to the methods of transporting hatching eggs and young and mature stock. Hatcherymen should be mindful of the fact that in order to produce chicks free from the disease, eggs should be selected only from flocks that do not harbor the infection. In sections where pullorum-free flocks are few in number, additional flocks may be established through an effective retesting program or through the introduction of pullorum-free stock. Both methods of establishing pullorum-free flocks have been found effective, especially in the New England States. Table 1 gives an 18-year testing summary of Massachusetts flocks. Attention is called to the increase, from year to year, in the number of tested birds, the reduction in the average percentage of infection, the increase in percentage of total tested flocks nonreacting, as well as the increase in the percentage of total tested birds in nonreacting flocks. Similar progress has been made in other Eastern States, as is shown in table 2.

Success in combating pullorum disease is dependent on a sound control and eradication program that is conscientiously carried out in a cooperative manner by the flock owner, hatcheryman, and official testing agency.

SUMMARY

Pullorum disease is recognized as a major economic problem to the poultry industry. An increased interest in the control and eradication of the disease has resulted in reducing mortality from pullorum infection. A nationwide survey revealed that 44 States had adopted either official or semiofficial control and eradication measures. In 1938, 42 States were participating in the National Poultry Improvement Plan, 37 of which were engaged in the pullorum disease phase of the plan. The establishment and adoption of this plan have stimulated an interest in the control and eradication of pullorum disease.

Investigations during the last 10 years have extended our knowledge concerning various important aspects of the disease. Dissemination of the disease within mature flocks is attributed largely to the eating of infective eggs. However, in adult flocks the infection may also be fecesborne, which fact must be taken into consideration in the control and eradication of the disease.

That *Salmonella pullorum* is susceptible to bacterial variation must be recognized in the isolation and identification of the species and in the preparation of a satisfactory antigen.

Observations have revealed that the efficiency of the whole-blood agglutination test may be increased when graduated pipettes are employed to measure constant quantities of whole blood and antigen. It is evident that the whole-blood agglutination test should be further investigated to improve its usefulness in the establishment and maintenance of flocks free from the disease.

Fowl other than chickens play a definite role in pullorum disease control and eradication. This statement applies especially to turkeys, which have suffered heavy losses from the disease. The elimination of the disease in turkeys through testing appears to be more difficult than in chickens; however, a reliable testing method may be successfully employed in controlling and eliminating the infection.

In the practical control and eradication of pullorum disease in poultry, attention is called to several important measures that should be observed if success is to be attained. In Massachusetts reinfection is observed annually in approximately 3 percent of the previously nonreacting flocks. The practice of custom and commercial hatching is greatly responsible for the dissemination of pullorum infection in this country. Methods for the prevention against dissemination of the infection through such channels have been discussed.

Testing data of various States are presented to show that pullorum disease-free flocks can be established and maintained and that pullorum disease control and eradication are progressing rapidly in many States.

TABLE 1.—*Pullorum disease testing summary of Massachusetts flocks covering an 18-year period*

Item	1920–21	1923–24	1926–27	1929–30	1932–33	1935–36	1937–38
Total number of flocks tested	108	139	249	460	335	252	308
Total number of birds tested	24,718	59,635	127,327	331,314	296,093	329,659	480,227
Total number of tests	24,718	59,635	127,327	386,098	300,714	344,081	497,769
Positive tests (percent)	12.60	6.53	4.03	2.17	.47	.30	.17
Percentage of total tested flocks nonreacting	23.15	27.34	45.78	67.17	82.39	91.27	92.85
Percentage of total tested birds in nonreacting flocks	9.77	18.58	31.63	66.97	80.41	95.95	95.26

TABLE 2.—*Pullorum disease testing summary of 13 States covering an 11-year period*[1]

Item	1927–28	1930–31	1933–34	[2]1937–38
Number of tests	735,851	1,565,822	1,597,025	3,076,590
Percentage of positive tests	3.2	3.8	1.2	1.8
Number of negative flocks (100 percent tested)	372	851	1,120	2,523
Number of breaks in negative flocks (100 percent tested)	43	85	84	274
Number of accredited flocks	[3]201	[3]377	610	1,197
Number of accredited birds	112,605	240,405	489,836	1,090,076

[1] Includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia, Vermont, and West Virginia.

[2] Rhode Island submitted no results.

[3] Massachusetts did not recognize an official accredited grade, which requires a flock to pass two consecutive negative tests not less than 6 months nor more than a year apart.

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SOME RECENT OBSERVATIONS ON FOWL PARALYSIS (NEUROLYMPHOMATOSIS)[1]

By F. BLAKEMORE, *and* T. DALLING, *Institute of Animal Pathology, University of Cambridge, Cambridge, England*

Fowl paralysis (neurolymphomatosis) has been recognized for some years as one of the chief causes of losses among poultry in England and some other countries. Though many investigations have been carried out in different parts of the world, a review of the literature shows a lack of definite knowledge, based on experimental proof, regarding its cause and nature.

The following recent observations made at the Institute of Animal Pathology, Cambridge, England, may throw some light on these and other aspects of the disease. Evidence of the infectious nature of fowl paralysis has been obtained by experiment, the presence of the infecting agent in different tissues of affected fowls has been demonstrated, and the nature of the lesions in their various stages in the course of the infection has been studied.

The disease under discussion is that described by Pappenheimer and others (1929) and by McGaughey and Downie (1930), i.e., the disease of fowls characterized by the infiltration of nerves and some other tissues by cells of the lymphoid series, varying in extent, and does not include allied conditions believed by some workers to be closely related.

EXPERIMENTAL DATA

The following is a brief description of recent experiments. A fuller account will be found in the Journal of Comparative Pathology and Therapeutics, 1939, volume 52, part 2.

A strain of fowls derived from the survivors of an outbreak of fowl paralysis has been inbred at the institute for six generations, the progeny being reared in isolation on each occasion. Table 1 shows that the incidence of the disease disappeared entirely after the second generation. A complete examination was made of every fowl in each of the five generations shown.

Chicks of the fifth generation were examined for susceptibility to fowl paralysis by (1) intraperitoneal injection of emulsions of nerves and other tissues (e.g., liver, spleen, etc.) of affected fowls and (2) contact with the naturally occurring disease. In table 2 are recorded the results of the experiments, from which it is seen that, judging by the occurrence of nerve lesions, fowl paralysis was transmitted to 23 of the 78 injected fowls and that 14 of the 33 placed in contact with naturally affected fowls also became affected, whereas control fowls remained healthy.

Further noteworthy features were the general unthriftiness of the injected and exposed fowls compared with the controls and the occurrence of lymphomatous tumors in the former groups—a condition believed by some observers to be associated with fowl paralysis.

The results of these experiments clearly demonstrated that though fowl paralysis had been eliminated by breeding from the survivors of an affected flock, the fowls were still highly susceptible to the disease when injected with tissues from affected fowls and when exposed to natural infection.

During the transmission experiments, in some of the visceral organs, especially the heart and liver, lesions of a type somewhat different from those generally described in fowl paralysis were observed. Fowls killed within 150 days of injection showed such lesions in their organs. Usually

[1] Much of this work was carried out by means of a special grant received from the Agricultural Research Council.

the pericardial sac contained a small quantity of clear serous fluid and in the myocardium were found whitish ill-defined areas; in some cases a definite flabbiness of the heart without other abnormalities was observed. The lesions in the liver varied. In some cases there was slight enlargement and the organ was covered with a layer of gelatinous material, but in other fowls it was of normal size and the capsule was unchanged. Whitish areas of various extent were usually present in its substance and, though frequently small and evenly distributed, extensively involved areas were at times observed but on no occasion was there any tendency to encapsulation or diffuse cirrhosis. Similar changes were occasionally found in the lungs, spleen, and kidneys, but the degree was never marked. Only on rare occasions was swelling of the spleen observed.

TABLE 1.—*Incidence of neurolymphomatosis in an inbred flock*

Generation No.	Fowls	Clinical cases	Cases of neurolymphomatosis: Gross nerve lesions	Micro-scopic nerve lesions only	Total incidence
	Number	*Number*	*Number*	*Number*	*Number*
1	35	7	7	11	18
2	31	4	2	12	14
3	19	0	0	0	0
4	36	0	0	0	0
5	59	0	0	0	0

TABLE 2.—*Results of transmission experiments*

Intraperitoneal inoculation of emulsion of tissues[1]

Experiment No.	Chicks	Cases of fowl paralysis: Gross nerve lesions	Micro-scopic nerve lesions only	Tumors	Other lesions	Total inci-dence
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
1	18	8	1	1	....	10
2	6	1	....	....	....	1
3	29	6	5	2	[2]2	15
4	25	2	....	....	[2]1	3
Total	78	[3]17	[4]6	[5]3	3	29

Exposure on affected premises[6]

Experiment No.	Chicks	Cases of fowl paralysis
	Number	*Number*
1	20	12
2	13	2
Total	33	14

[1] 93 controls were kept; 46 were killed and examined and in no case were macroscopic or microscopic lesions found.
[2] Iritis.
[3] Killed or died 33-266 days after injection.
[4] Killed or died 187-281 days after injection.
[5] Killed or died 221-256 days after injection.
[6] 34 chicks were placed in contact with fowls among which no fowl paralysis was present. All remained healthy.

In order to study these lesions further, a series of experiments was carried out in which chicks from the above-mentioned source were used. In all, five groups were injected. The material injected into the first group consisted of an emulsion of liver from a fowl in the preceding transmission experiments. No nerve lesions were present but in its liver were areas similar to those described. Further passage work was carried out in series, emulsions of typically affected livers from chicks in one group being used for the next group. In table 3 the results are recorded. All obviously paralyzed and sick chicks were killed and examined. The infecting agent apparently increased in virulence for by the fourth passage 9 of the 11 injected chicks had died within 32 days of being injected. The interesting features of this experiment are the occurrence of heart and liver lesions early in the course of the infection, the persistent unthrifty condition of the survivors, the occurrence of definite fowl paralysis nerve lesions comparatively late in the course of the disease, the occurrence of one definite lymphomatous tumor, and the presence of the infecting agent in the blood.

The results of these observations indicate that concerned with fowl paralysis is an infecting agent which is present in the liver and blood of affected fowls in the early stages of the disease and that the earliest lesions are not found in the nerves, as is generally believed, but in the visceral organs, especially the heart and liver.

The histology of the lesion in its different phases was studied, affected chicks being killed at various stages of the disease for this purpose. The lesions in the liver and heart were essentially similar, and in the early stages fatty degeneration of the cells occurred, followed by a definite necrosis usually focal in character but sometimes widespread. Within 10 days of injection such necrotic lesions could be demonstrated, and in some of the very acute lesions found in the later passage experiments, hemorrhage was observed. These areas then became infiltrated with cells of various types. Lymphocytes were soon found in abundance, and in addition large mononuclear and plasma cells, as well as eosinophilic polymorphonuclear leucocytes, were frequently present. Fibroblasts were observed later, especially between the cardiac fibers. The early tissue reaction must therefore be considered inflammatory in character. Later in the infection the affected areas became densely packed with cells of the above-mentioned types which infiltrated into the surrounding tissue. Later still in the infection, well-defined areas were found mainly around the small hepatic vessels and in the portal tracts with limiting cells, large in size, with abundant cytoplasm and nuclei containing much chromatin structure. Fine fibrillary tissue was found in some instances, giving the appearance of lymphoblastomosis ascribed by Adamstone (1936) to vitamin E deficiency. In the experiments described, this condition still occurred when a supplement of vitamin E was added to the ration. A true lymphomatous response in the organs was found most typically in fowls killed after 3 months following injection. Actual tumor formation was noted in some cases, and when this occurred the growths often attained a considerable size and were either diffuse or nodular in character. The incidence of nerve lesions varied as did the extent of their infiltration. In some cases the only evidence of fowl paralysis was found in the nerves whereas in others, lesions were also evident in various organs. The nerve lesions consisted mainly of lymphocyte infiltrations and as they became more chronic, larger cells closely resembling mammalian plasma cells were commonly found.

This study of the histology of the lesions at different stages of the infection suggests that the primary lesion in fowl paralysis is inflammatory in character and that it later becomes lymphomatous in type consequent upon an invasion of the affected areas with cells of the lymphoid series. Further, infiltration of nerves with lymphocytes and lymphomatous tumor formation in the tissues takes place at a later stage. It appears that the condition hitherto described as neurolymphomatosis really represents a late stage of an infectious process.

TABLE 3.—*Passage of the infecting agent through young chicks*

Passage No.	Chicks	Route	Tissue	Positive cases					
				Slight visceral lesions	Marked visceral lesions	Paralysis and gross nerve lesions	Microscopic nerve lesions only	Tumors	Total incidence
	Number			*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1	11	Intraperitoneal	Liver	2		2	1		5
2	8	do	do	1	2		1	1	5
3	10	do	do		9	1			10
4	11	do	do		8	1			9
	3	Intramuscular	do	1	2				3
	2	Intravenous	do		2				2
	3	Subcutaneous	do	1	1	1			3
5	4	Intraperitoneal	Blood	[1]1	2				3
	4	do	Liver	[1]1	3				4
Total	56			7	29	5	2	1	44

[1] Also showed nerve lesions.

DISCUSSION

The results of many of the experiments carried out by workers on fowl paralysis concerning the possible infectious nature of the disease have proved inconclusive because of the occurrence of typical lesions in the tissues of controls, or untreated fowls, of the same strain. By the use of a strain of fowls whose history clearly showed that the disease had been completely eliminated, the infectious nature of fowl paralysis has been demonstrated. The injection of tissues from naturally affected fowls was followed by the occurrence of typical lymphocytic infiltrations in the nerves of 23 of the 78 treated fowls and of lymphomatous tumors in 3 of them, whereas in none of the controls of the same ages were lesions observed.

The history of the strain of fowls used in the experiments is of considerable interest. The originals were the survivors of a marked, typical outbreak of fowl paralysis, confirmed in every case by histological examinations of nerves. Inbreeding was carried out and after two generations no further evidence, clinical or histological, of fowl paralysis was observed. Transmission experiments established that the absence of the disease was not dependent on an acquired or inherent resistance, for the fowls in the fifth inbred generation proved to be highly susceptible to the disease following the injection of tissues from selected naturally affected fowls and exposure to the natural disease on infected premises. It is obvious, therefore, that the explanation of the absence of fowl paralysis in certain poultry stocks is that they have not been exposed to the infecting agent.

Differences in the susceptibility of strains of fowls to fowl paralysis is commonly recognized, and further confirmatory evidence was obtained in the course of the recent observations at Cambridge in which the incubation period and incidence of the disease varied in chicks of different strains inoculated with the same infecting agent.

An outstanding feature of the transmission experiments was the general unthriftiness of the injected fowls compared with the controls. This is in keeping with the history of some outbreaks on poultry farms. Further, the mortality among chicks in some of the experiments before the occurrence of the commonly accepted diagnostic lymphocytic infiltrations is in keeping with field observations and the findings of other workers on fowl paralysis. For instance, Dalling and Warrack (1933) record death rates of 38.5 and 3.8 percent among inoculated and uninoculated fowls, respectively, of the same strains and ages apart from diagnosed cases of fowl paralysis.

It has been stated by several observers that the occurrence of fowl paralysis is dependent on intestinal parasitic infestation, especially coccidiosis. Although the experimental evidence of Dalling and Warrack (1936) is against such a hypothesis, the view continues to be expressed without adequate supporting experimental evidence. In the experiments reported, it was noted that intestinal parasitic infestation did not become marked until some months following the injections and was preceded by unthriftiness. This observation, illustrating a sequence of events quite different from that often suggested, may explain the frequent association of the two conditions so often apparent in field outbreaks.

The nature of the infecting agent has not yet been established. Some preliminary filtration experiments have been carried out, and though the evidence is not yet complete there are strong indications that the infecting agent contained in the liver in the early stages of the disease is filtrable.

The infecting agent apparently differs in virulence, for in the passage experiments the incubation period and incidence of the infection varied in the different groups of chicks. In all probability, the different strains of the "agent" in naturally occurring outbreaks also vary in virulence and may be a further cause of the varying incidence of the disease in different outbreaks.

The results of the histological examination of lesions at various stages of the infection following the injection of young chicks with the emulsions of liver throw further light on the nature of the disease. It must be admitted that the donor of the material used in the first group of chicks for passage experiments, though a member of a group in which typical neurolymphomatosis was present, showed liver lesions only and thus the possibility exists that the disease transmitted was not typical fowl paralysis. However, the occurrence of typical nerve lesions later in the course of the infection in the injected chicks indicates that the typical disease was being transmitted, and the transition changes observed in the lesions in the liver and heart support this view. There is always the possibility, of course, that two different diseases were transmitted or that nerve lesions do not represent a specific response and may develop as the result of stimulation of the tissues in a number of ways.

The presence of lesions of an inflammatory character has been recorded by other observers. For instance, Pappenheimer and others (1929) described two definite lesions in the myocardium and the liver, one of which corresponds to the more advanced type and the other is more definitely inflammatory. In discussing their findings they state:

> "One of the most interesting and, as yet, wholly obscure phases of our problem, is the undoubted transition between the lesions which histologically appear to be inflammatory and those which assume the character of a true neoplasm."

McGaughey and Downie (1930) and Findlay and Wright (1933) also remark on the finding of cells associated with an inflammatory reaction especially in the eye appendages, and recently, Potel (1938) describes various types of cells in the viscera of fowls affected with neurolymphomatosis. Oakley (1935) refers to the visceral type of the disease but states that the infiltrations consist almost entirely of cells of the lymphoid series embedded in a very scanty stroma.

Assuming that one disease only was transmitted, it would appear that the earliest lesion, inflammatory in character, is found in the visceral organs and that subsequently the affected areas are infiltrated with cells mostly of the lymphoid series. In all probability most workers have, in the past, examined only lesions in later stages of the disease and may have missed the primary response occurring within a few days of the infection. It seems probable, therefore, that the view that neurolymphomatosis is only a manifestation of a general disease is correct and, further, from the above results represents, in many instances, an advanced stage in the course of the infection.

SUMMARY

Recent experiments carried out at the Institute of Animal Pathology, Cambridge, England, with a strain of fowls in which the incidence of fowl paralysis was high showed that by inbreeding and careful isolation of the chicks, the disease entirely disappeared after the second generation. Chicks of the fifth generation were shown to be highly susceptible to fowl paralysis following the injection of tissues from cases of the disease and by exposure to natural infection. Untreated fowls, used as controls, remained healthy. General unthriftiness was marked in the injected and exposed groups, and intestinal parasitic infestation did not occur until late in the course of the infection.

Evidence is produced that fowl paralysis is an infectious disease and that the infecting agent is probably filtrable. A series of passage experiments with liver emulsions in groups of young chicks was carried out, and it was shown that the infecting agent increased in virulence and caused illness and death among the chicks within 1 to 4 weeks. The inoculated stock developed lesions in the viscera, especially the liver and heart. Histologically, the lesions which were inflammatory in character became infiltrated with cells of the lymphoid series. Lesions in the nerves occurred late in the course of the infection and, in one case, a lymphomatous tumor was found.

There is, therefore, evidence that fowl paralysis is a disease which may affect several of the body tissues and that true lymphomatosis represents a final stage of the disease in which various tissues,

including the nerves, may be involved and actual lymphomatous tumor formation may occur. Previous failures to transmit the disease may be due to the susceptibility of the strain of fowls employed, the degree of virulence of the infecting agent, the stage of the disease at which tissues are selected for transmission work, and the type of tissue selected.

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PRESENT STATUS OF FOWL LEUKOSIS (FOWL PARALYSIS)

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INTRODUCTION

In the field of poultry pathology one of the most confusing and perplexing problems is presented in the disease complex referred to by such terms as range paralysis, fowl paralysis, neurolymphomatosis, lymphomatosis, leukosis, and others. Scores of casual observations, as well as the results of scores of carefully planned and executed experiments on various phases of this malady, have been recorded in both popular and scientific literature. Many of these publications indicate that considerable progress has been made in the determination of the pathological changes that take place in the various forms of the disease, and also, in the determination of ways in which the disease may be transmitted from affected birds to well birds. From all of these contributions, however, it appears that the most salient single fact gained is the realization of the complexity of this problem. With this background of research on the problem, future work must be so formulated as to untangle some of the fundamental obstacles that continue to prevent definite conclusions from experiments on transmission and from experiments performed to elucidate the exact nature of the causative agent or factors involved.

MANIFESTATIONS OF THE DISEASE

Leg paralysis frequently observed in chickens 2 to 15 months of age is usually one of the symptoms of fowl leukosis. Gray eyes resulting in blindness, gasping, paleness, weakness, and emaciation are other symptoms noted in various expressions of the same disease.

The earliest reference in the literature to a paralysis of chickens is by Marek of Hungary in 1907. The disease he described is undoubtedly the same as that described in this country by Pappenheimer and coworkers in 1926, and for which the name *Neurolymphomatosis gallinarum* was suggested. These workers very completely described the symptoms and lesions encountered and concluded that the disease they were dealing with was primarily one of the nervous system, although they observed the frequent association of visceral lesions, tumors, and a form of blindness characterized by gray eyes. Much of this work has been confirmed, and more recent evidence seems to warrant the conclusion that the visceral lesions, tumors, and eye lesions are manifestations of the same disease that frequently results in leg or wing paralysis or both.

The predominating lesions were described as infiltrations of lymphoid cells, plasma cells, and mononuclears, especially in the central nervous system and in the peripheral nerves. Similar infiltrations in the liver, kidneys, lungs, and iris, as well as tumors consisting chiefly of similar cells in the ovary and other organs, were also noted. Descriptions of lesions recorded by scores of other workers are essentially in agreement with these findings in this particular form of the disease. Several other workers, however, have noted that certain blood dyscrasias, as well as visceral tumors, are other expressions of this disease complex. These findings can no longer be considered as coincidental since an increasing number of workers are finding similar results.

Failure to recognize the relationship that exists in these various expressions in most cases can be attributed to a lack of thorough histologic study of the blood and blood-forming organs of experimentally inoculated birds. On the other hand, those investigators working with leukosis of chickens for the purpose of throwing further light on human leukemia in most instances have concentrated on blood studies as such, so that when nerve involvement was encountered it was considered as being due to intercurrent disease. Furth, in 1933, however, found that his filtrable leukosis agent designated as strain II gives rise to a multiplicity of expressions, e.g., lymphomatosis, myelomatosis, and endothelioma. The so-called paralysis of chickens is due to lesions in the nerves that are essentially lymphomatotic in nature.

EXPERIMENTAL CONSIDERATIONS

Ellermann, in 1921, described three forms of fowl leukosis, namely, erythro-, lymphoid, and myeloid forms. He found that the first was readily transmissible and later discovered that the two last-mentioned conditions also resulted when similar materials were used. He, therefore, concluded that all three were due to a common etiological agent. The "lymphoid leucosis" he describes is essentially a visceral lymphomatosis.

The experiments of more recent workers confirm these results. In addition, the results of my own transmission experiments point to the conclusion that injection material from any one of the above-mentioned forms of leukosis may produce (1) the type had by the donor (2) either of the other forms or (3) a combination of two or more of these. Moreover, there is frequently considerable overlapping and one form may change to another during the course of the disease.

The marked enlargement of the liver, which frequently occurs and in which the liver parenchyma is almost completely replaced by lymphoid cells, is spoken of by some workers as lymphocytoma and is considered to be due to a distinct nontransmissible disease. Since this condition not infrequently arises in birds inoculated with leukotic materials and since a few cases of leukosis have been produced by inoculating material from these cases, we are obliged to conclude that it is also an expression of leukosis. The term lymphocytoma does not seem justified on the basis of the predominating type of cells present. These cells are not mature lymphocytes but rather immature blast forms and the condition should be considered as a hemocytoblastosis, the hemocytoblast being the most prevalent cell form in these cases.

The hemocytoblastosis, which frequently is the earliest stage in any of these forms following experimental inoculation with the etiological filtrate, must not be confused with a transient hemocytoblastosis, which may be noted in the peripheral blood in response to injections of any of the pathogenic micro-organisms that bring on a sudden release of cells to combat the infection. In these cases the differentiation is to the particular type of cell called forth, which is usually the eosinophilic rod granulocyte. In this condition there is usually evidence of an acute infection, and the bird either dies within a short period or recovers and the blood picture returns to normal.

In the various expressions of leukosis, however, there may be a marked destruction of blood cells and the hemocytoblastosis occurs in an effort to replace these cells. When erythrocytes and granulocytes are involved, as in the erythro- and myeloid leukoses, there is a marked hyperplasia of bone marrow, with a marked production of immature cells that seem to lack the property of becoming physiologically mature cells. A stasis of these cells may occur in practically all blood channels of visceral organs.

When the lymphocytes are involved, as in the various expressions of lymphoid leukosis, there may or may not be marked blood involvement. In response to this agent these cells are stimulated to increased activity in various organs that contain reticular stromal cells that function as ancestral cells to the hemocytoblast. A few of these may be carried to nerves, and in these regions, as well as in other ectopic areas, these cells may proliferate and apparently undergo unrestricted activity to a point that simulates the character of neoplasms.

THE CAUSATIVE AGENT

With this disease, as with any other, the most difficult problem is to determine the cause. Several of the early workers felt that coccidia and intestinal worms were etiological factors. It has been suggested that these intestinal parasites pave the way for infection with various paratyphoid and *Salmonella* organisms, which were considered as etiological agents. At the present time, however, the overwhelming evidence indicates that the etiological agent is filtrable and that the disease in its various forms can be transmitted from affected birds to well birds, although not in every instance. The question whether this agent is a single entity capable of producing these various manifestations of disease or whether several strains possessing slight differences exist, cannot be definitely answered at this time. Neither are all properties possessed by this agent or agents known at present. It is interesting to note, however, that by filtration tests through collodion membranes, Furth found that the filtrable agent of erythro- and myeloid leukosis is much smaller than the virus of bovine pleuropneumonia (250 millimicrons) and that it approximates the size of bacteriophage. In similar tests with the agent that we have found to produce lymphoid leukosis (fowl paralysis) erythro-, and myeloid leukosis, the particle size was found to be between 400 and 100 millimicrons, or possibly less. The size of the common paratyphoid organisms that affect chickens is 1,000 to 1,500 millimicrons. Most of the available evidence indicates that the causative agent is not a fixed entity capable of producing only one form of disease but that under certain conditions the various manifestations described herein are produced.

TRANSMISSION AND CONTROL

The major emphasis in combating any poultry disease should be placed on methods of prevention. In order that one may intelligently apply control methods, something must be known about ways in which the disease is transmitted from sick to well birds. It has recently been found that leukosis may be transmitted from affected birds to well birds by the common red poultry mite (*Dermanyssus gallinae*), and by the common procedure of vaccination for the prevention of chicken pox if well birds are vaccinated with the same brush or instrument that has been previously used on affected birds and then dipped into a common vaccine container immediately before using it on well birds.

The question of transmission through the egg has not been settled. At the present time we are not justified in concluding that the causative agent is transmitted through the egg so that chicks are affected at the time the eggs hatch. On the other hand, there seems to be considerable evidence to support the growing opinion that certain strains of birds are more susceptible to this disease than others and that this susceptibility is transmitted from parent to offspring.

Various drugs have been tried as treatment, but none has been found to have any important place in control of this disease. Recently, the feeding of lettuce for its vitamin B property and the feeding of wheat-germ oil for vitamin E have been advocated as prophylactic and therapeutic measures, but even these have failed in our experiments either to prevent or to cure the disease.

CONCLUSIONS

Until more fundamental information is forthcoming, therefore, it appears that control methods should be based largely on the following recommendations:

Obtain new stock only from flocks that have remained free from any form of this disease, or at least from flocks in which there have been but few cases.

Retain for breeding stock the best 2- and 3-year-old birds. These birds have either resisted the disease or are immune, and their resistance or immunity seems to be transferred to the offspring.

Keep birds and houses free from lice and mites, as these may spread the disease in flocks that have one or more affected birds.

Cull the flock carefully before vaccinating, for the prevention of chicken pox, to eliminate any noticeably affected birds that may serve as a source for dissemination of the disease by this procedure. Individual applicators or brushes will eliminate this avenue of transmission.

Practice approved methods of sanitation, keeping in mind at all times that the sick bird and healthy-appearing "carrier" of disease-producing agents are the most essential individuals to dispose of as soon as they can be detected.

SUMMARY

Leg paralysis frequently observed in chickens 2 to 15 months of age is usually one of the symptoms of fowl leukosis. Gray eyes resulting in blindness, gasping, paleness, weakness, and emaciation are other symptoms noted in various expressions of the same disease.

Leukosis is primarily a disease of the blood and blood-forming organs. Histopathologically, it occurs in at least three forms, namely, erythro-, lymphoid, and myeloid, depending on which series of cells is stimulated to greatest activity. Considerable overlapping occurs in the three forms, and frequently a change from one form to another takes place during the course of the disease.

The disease is nearly always fatal. The causative agent is filtrable, having many of the characteristics attributable to a filtrable virus. Filtration experiments have shown its size to be between 100 and 400 millimicrons, as contrasted with 1,000 to 1,500 millimicrons, which is the average size of the common paratyphoid organisms that affect chickens.

It may be transmitted from affected birds to well birds by intravenous as well as by subcutaneous inoculations of blood and by other tissue extracts. Moreover, transmission is likewise successful when bacteria-free filtrates from these tissues are used. Transmission may also take place through such agencies as red mites (*Dermanyssus gallinae*) and by the common procedure of vaccination for the prevention of chicken pox.

All the common breeds of fowls appear to be equally susceptible. Certain strains within these breeds, however, appear to be less susceptible than others. Prevention may eventually be possible by developing resistant or naturally immune strains of birds. No drug, feed, mineral nor vitamin, nor combination of these, appears to have curative or preventive value.

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ÜBERTRAGBARKEIT DER MAREK'SCHEN HÜHNERLÄHMUNG

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Bei den Forschungen über die Ätiologie der Marek'schen Hühnerlähmung mußten die Versuche in sehr umfangfreichem Maße durchgeführt werden, da zwar vermutet wurde, daß die Hühnerlähmung übertragbar ist und durch einen bestimmten Erreger hervorgerufen wird, andererseits aber angenommen wurde, daß konstitutionelle Mängel infolge Hochzucht, Fütterungseinflüsse, Haltungsfehler, Parasitenbefall oder gar Vergiftungen eine wesentliche ursächliche Rolle spielen. Die Versuche sind deshalb in allen den aufgezählten Richtungen erfolgt und haben teilweise zu sich wiedersprechenden Ergebnissen geführt. Dies war wiederum Anlaß dazu, daß eine Anzahl von Autoren die Ätiologie auf Grund ihrer Versuche noch für ungeklärt hält.

Die Übertragungsversuche zur Feststellung, ob die Krankheit evtl. ansteckend ist, nehmen den breitesten Raum ein. Die Beobachtungen in den Geflügelbeständen gaben begründeten Anlaß, daß die Hühnerlähmung wohl übertragbar sein muß, weil festzustellen war, daß sie nur dann auftrat, wenn Tiermaterial in Form von Bruteiern, Eintagsküken oder Jungtieren aus Beständen zugekauft wurde, die selbst unter Marek'scher Hühnerlähmung zu leiden hatten. Die teils künstlich, teils natürlich gestalteten Übertragungsversuche haben nun die Vermutung der Übertragbarkeit in sehr hohem Maße bestätigt, und ich will die Versuchsergebnisse im Folgenden kurz aufzeichnen und versuchen, daraus eine Schlußfolgerung zu ziehen:

I. KÜNSTLICHE ÜBERTRAGUNGSVERSUCHE

Da im allgemeinen bei Infektionskrankheiten die künstliche Überstragung am schnellsten zu einem positiven Ergebnis führt, wurden solche Versuche auch bei der Hühnerlähmung zu deren Klärung angewandt. Van der Valle und Winkler-Junius stellten meines Wissens im Jahre 1924 wohl die ersten Übertragungsversuche mit positivem Ergebnis an und vermuteten ein Virus als Erreger der Hühnerlähmung, wenn auch ihr Versuchstiermaterial sehr klein war.

In den folgenden Jahren wurden dann sowohl in Amerika wie in Europa Übertragungsversuche in umfangreichem Maße angestellt, und zwar in erster Linie mit Nerven- und Organmaterial von lähmekranken Hühnern entweder in Form von Emulsionen (Doyle, Pappenheimer-Dunn-Seidlin, Seifried, Lerche und Fritzsche, te Hennepe, Beller, Hartwigk, Baumann, Seagar, Dalling, Hepding, Jungherr, Wagner, Kaupp, May, Titt-seler-Goodner und Beach) oder keimfreie Filtrate von Nerven- und Organmaterial verwendet (Seagar, Baumann, van der Valle und Winkler-Junius, Pappenheimer-Dunn-Seidlin, Furth und Fritzsche). Die Übertragung erfolgte subdural, intramuskulär, intraperitonaeal, intravenös und intraokulär bei den Versuchstieren und führte zu verschiedenen Ergebnissen. Teils waren sie völlig negativ (Kaupp, Tittsler, May-Goodner, Wagner, Doyle), teils erkrankten nur einzelne Versuchstiere (te Hennepe, Beller), und andererseits wurden wiederum 40–100 prozentige Versuchsergebnisse von Seifried, Lerche und Fritzsche, Seagar, Hepding, Baumann, Jungherr) erzielt. Je nach dem Resultat folgerten die einzelnen Autoren dann, ob die Krankheit nun tatsächlich durch ein übertragbares Agens hervorgerufen wird oder nicht. Bei der Betrachtung der Versuchsanstellung der Autoren ist aber nun auffällig, daß einmal das Versuchstiermaterial unter verschiedenen Gesichtspunkten ausgewählt wurde. Es wurden Eintagsküken, Junghennen und erwachsene Hühner dazu benützt. Die Versuchstiere stammten entweder aus Beständen, die sicher frei von Hühnerlähmung waren, zum anderen wurden sie absichtlich aus infizierten Beständen genommen (Beach, Doyle). Es ist nun festzustellen, daß die künstliche Übertragung am leichtesten gelang bei der Verwendung von wenige Tage alten Küken und bis zu lo Wochen alten Jungtieren, während mit zunehmendem Alter der Tiere die künstliche Infektion schwerer bezw. nicht mehr möglich war. Diese Beobachtung stimmt ja auch mit der Praxis überein, daß hauptsächlich die Jungtiere in den Beständen erkranken, während erwachsene Hühner nur noch vereinzelt befallen werden. Es ist also zunächst einmal zweifellos eine besondere Disposition für diese Krankheit bei dem Junghuhn bis zum Alter von etwa 1 o Wochen festzustellen. Demnach ist es nicht verwunderlich, daß der größte Teil von Übertragungsversuchen bei Hühnern, die wesentlich älter als 1 o Wochen sind, nur vereinzelt positiv ja sogar negativ ausfällt.

So lange nun weiterhin noch nicht feststeht, ob bei einem erkrankten Huhn der vermutete Erreger dauernd oder vorübergehend im Nervensystem oder den übrigen Organen vorhanden ist, kann nicht gefolgert werden, daß das verwendete Infektionsmaterial mit Sicherheit stets den Erreger in virulenter Form überhaupt enthält. Dass dies zutreffen kann, hat ja Seagar bei seinen Untersuchungen festgestellt. Es wurde auch bekannt, daß die Übertragungen am leichtesten gelingen, wenn das Material von mehreren Jungtieren, die an ganz akuter Hühnerlähmung mit schweren Nervenveränderungen erkrankten, gemeinsam verwendet wird (Hepding, Fritzsche). Sobald das Versuchstiermaterial für Übertragungsversuche aus lähmeinfizierten Beständen stammt, wird das Ergebnis sofort unsicher, da nicht feststeht, ob es nicht bereits vor der Heranziehung zum Überstragungsversuch mit der Hühnerlähmung behaftet war. Auffällig ist, daß bei den Autoren, die solches Tiermaterial verwandten, die Kontrolltiere fast stets miterkrankten. Bei solchen tastenden Übertragungsversuchen ist also nur das positive Übertragungsergebnis beweisend, vorausgesetzt, daß das Ausgangsmaterial aus sicher gesunden Beständen stammt und daß die verwandten Kontrolltiere nicht gleichzeitig erkranken. Die Kontrolltiere können aber auch dann erkranken, wenn diese und die infizierten Tiere von ein und derselben Person bedient werden, dies ist zu berücksichtigen.

Die angestellten Versuche zeigen nun, daß die Marek'sche Hühnerlähmung künstlich übertragbar ist. Es wird nun aber der Einwand erhoben, daß manchmal nur ein verhältnismässig geringer Prozentsatz positiver Übertragungen bei einem Versuch erzielt wird und daß deshalb nicht ohne weiteres gefolgert werden kann, daß damit eine sichere Übertragung vorliegt. Dazu ist meiner Ansicht nach folgendes zu sagen:

Bei künstlichen Übertragungsversuchen mit einem noch unbekannten Agens darf nicht ohne weiteres mit mehr positiven Übertragungsergebnissen gerechnet werden, als wie sich unter natürlichen Verhältnissen ereignen, denn bei der künstlichen Übertragung steht niemals vorher fest, daß der Erreger besser und einwandfreier übertragen wurde als wie unter natürlichen Bedingungen, zumal wir keine sichere Dosierung des Erregers bislang herstellen können. Weiterhin wissen wir nicht, ob bei einem künstlichen Übertragungsversuch gar keine Ansteckung, sondern bei vielen Tieren eine Art von Immunisierung bewirkt wird, wie sie z.B. unter natürlichen Verhältnissen bei der Poliomyelitis des Menschen vermutet werden muß und von Pfaundler als "stille Feiung" bezeichnet wird. Ich glaube daher, daß man wohl die Schlußfolgerung ziehen kann, daß eine künstliche Übertragung bei Hühnerlägmung gelungen ist, wenn auch nur wenige Tiere klinisch erkranken. Die histologische Untersuchung des Nervensystems sämtlicher Versuchstiere gibt ja häufig Aufschluß, daß noch bei mehr Tieren die Infektion als angegangen angesehen werden muß. Die Lähmungen sind ja schließlich auch nur ein Symptom der Krankheit ähnlich wie die Abortusfälle bei der Bang-Infektion des Rindes. Wenn nun weiterhin bei den künstlichen Übertragungsversuchen eingewendet wird, daß angeblich schon bei der Verimpfung von gesundem Nervenmaterial bei den Versuchstieren Lähmungen auftreten, so ist dagegen zu sagen, daß es doch merkwürdig ist, wenn solche erst nach einer Inkubationszeit von mindestens 6 Wochen auftreten würden. Wenn ein rein toxischer Einfluß der Nervensubstanz vorläge, so dürfte wohl zu erwarten sein, daß die Symptome dann in wesentlich kürzerer Zeit zur Ausbildung kommen. Gänzlich entkräftet wird meiner Ansicht nach der Einwand dadurch, daß es gelungen ist, mit durch Berkefeld-Kerzen gewonnenen Zell- und keimfreien Filtraten die Hühnerlähmung künstlich zu übertragen. Darauf weist auch Seagar besonders hin. Von Bedeutung ist ferner, daß es Seifried und Jungherr gelang, bis 4 Passagen des Erregers durch künstliche Übertragungsversuche zu erreichen.

II. NATÜRLICHE ÜBERTRAGUNGSVERSUCHE

Nicht nur künstliche Übertragungsversuche sind bei der Hühnerlähmung gelungen, sondern auch natürliche, und zwar sowohl durch Kontaktversuche (Magnusson, Hartwigk und Fritzsche) als auch durch die Verfütterung von Kot lähmekranker Tiere an Küken. Seagar wies zuerst das übertragbare Agens im Kot nach. Später konnte ich seine Befunde bestätigen, und neuerdings berichtet auch Jungherr, daß der Erreger gelegentlich in frischem Kot nachweisbar war. Damit dürfte wohl auch klar gelegt sein, daß der Erreger von kranken Tieren mit dem Kot ausgeschieden wird und daß Küken durch die Aufnahme solchen Kotes angesteckt werden können. Somit erfährt die Beobachtung in der Praxis eine Klärung, daß die Eintagsküken immer wieder in einem hohen Prozentsatz an Hühnerlähmung erkranken, wenn sie sich in der Nachbarschaft eines infizierten Hühnerbestandes befinden, während die Krankheit nicht oder höchst selten zur Beobachtung kommt, wenn die Küken allein auf einem frischen Gelände aufgezogen werden. Dies beweist ferner der Eintagskükenverkauf aus lähmeinfizierten Beständen. Die Übertragung der Hühnerlähmung durch das Ei ist auch bereits festgestellt, und zwar durch Magnusson, Hepding, Lerche und Fritzsche, desgleichen durch zahlreiche Beobachtungen aus der Praxis beim Bruteierverkauf. Es ist hier lediglich einzuwenden, daß der Erreger als solcher im Ei noch nicht nachgewiesen wurde, so daß manche Autoren, die die Infektion der Krankheit überhaupt bisher ablehnen, an eine Vererbung glauben. Diese wird aber sehr unwahrscheinlich, weil die anderen künstlichen und natürlichen Übertragungsversuche für ein übertragbares Agens sprechen. Daß die Hühnerlähmung eine konstitutionelle Krankheit ist, ist von keinem Versuchsansteller bis jetzt einwandfrei bewiesen worden, obwohl Dalling gerade in dieser Richtung spezielle Untersuchungen anstellte. Den deutlichsten Beweis der Übertragbarkeit der Hühnerlähmung kann man erhalten durch Verbringen von gesunden Eintagsküken in lähmeinfizierte Bestände und gleichzeitige Aufzucht der beiden Kükengruppen. Bei solchen Versuchen erkranken meistens sogar die zugekauften Tiere in einem höherem Prozentsatz als wie die eigenen Tiere, während die Küken im Ursprungsbestand nach wie vor gesund bleiben. An Hühnerlähmung erkrankt auch nicht nur das Leistungsgeflügel, sondern auch Schönheitsrassen und Kreuzungstiere, wenn ihnen Infektionsmöglichkeit geboten wird. Diese Beobachtung ist wohl der schwerwiegendste Einwand gegen die Annahme, daß die Hühnerlähmung konstitutionell bedingt ist.

Auf dem letzten Weltgeflügelkongreß in Leipzig trug ich die praktischen Bekämpfungsmaßnahmen gegen die Hühnerlähmung vor, die sich lediglich auf die Infektion beziehen. Inzwischen sind 3 weitere Jahre vergangen, und ich habe die Maßnahmen nach denselben Grundsätzen weiterhin mit einem sehr brauchbaren Ergebnis durchgeführt, und darüber ist in der Literatur im Einzelnen berichtet. Wenn nun die Hühnerlähmung nicht infektiös wäre, könnte diese Maßnahme zu keinem Ziele führen, und auch der Geflügelgesundheitsdienst in Deutschland hat meine Erfahrungen bei der Bekämpfung bestätigt. Auf Einzel heiten einzugehen, ist im Rahmen dieses Vortrages leider nicht möglich.

Die Natur des Erregers ist ohne Zweifel noch nicht restlos geklärt, und es ist wohl sicher, daß er nicht zu den mikroskopisch sichtbaren Bakterien gehört oder ein Bakterientoxin darstellt. Erwiesen ist, daß er durch unsere Bakterienfilter hindurchgeht und sich 6 Monate lang in 50 Prozent igem Glyzerin virulent hält (Hartwigk, Seifried). Jungherr setzte Nervenmaterial einer 82 tägigen Austrocknung aus und erzielte damit noch künstliche Infektionen. Diese Eigenschaften deuten weitgehend darauf hin, daß es sich bei dem übertragbaren Agens um ein Virus handelt. Ob dies belebt oder unbelebt ist, ist nicht bewiesen, wie das ja heute bei vielen anderen Virusarten auch noch nicht der Fall ist.

ZUSAMMENFASSUNG

Zur klärung der Ätiologie der Marek'schen Hühnerlähmung sind im grossen Maßstabe sowohl künstliche als auch natürliche Übertragungsversuche in den verschiedensten Ländern der Welt durchgeführt worden. Sie haben in einem sehr hohen Maße zu positiven Übertragungsergebnissen geführt, so daß heute als sicher angenommen werden kann, daß die Hühnerlähmung sowohl künstlich als auch natürlich übertragbar ist. Es erkranken nicht nur die auf Leistung gezüchteten Hühnerrassen, sondern auch Schönheitsrassen und Kreuzungstiere. Die Hühnerlähmung ist nur bei Hühnern bislang zur Beobachtung gekommen. Bei den Übertragungsversuchen kann nur das positive Ergebnis als beweisend erachtet werden, da bislang nicht feststeht, ob in jedem Falle das verwendete Material überhaupt infektiös oder zur Auslösung einer Infektion genügend war. Weiterhin ist bislang nicht bekannt, ob bei Infektionsversuchen nicht bei einem erheblichen Teil der Tiere eine Immunität und keine Infektion erzeugt wird. Eine Übertragung ist auch dann als positiv anzusehen, wenn die Tiere nicht klinisch erkranken aber bei der histologischen Untersuchung des Nervensystems deutlich Veränderungen im Sinne der Marek'schen Hühnerlähmung festzustellen sind.

Die vorliegenden Untersuchungen über die Natur des Erregers der Marek'schen Hühnerlähmung lassen bereits weitgehend den Schluß zu, daß er zu den Virusarten gehört, da er filtrabel und glyzerinfest ist und einer längeren Austrocknung zu widerstehen vermag.

SUMMARY

For the investigation of the etiology of Marek's fowl paralysis extensive experiments with artificial and natural transmission of this disease have been carried out in various countries of the world. These experiments led, to a large extent, to positive results so that today it may be presumed as certain that fowl paralysis may be transmitted artificially as well as naturally. Not only fowls bred for production, but also show birds and hybrid fowl become affected with this disease. So far, fowl paralysis has been observed only in chickens. During the transmission experiments only the positive results may be regarded as proof, because it is not known so far, whether in each case the substance used was infective at all or whether it was adequate to cause an infection. Nor is it known so far, whether during transmission experiments an immunity may be created in a large part of the birds, instead of an infection. Even a transmission is regarded as positive, if the birds do not become clinically diseased but, on histological examination, show appreciable changes in the nervous system of the kind found in Marek's fowl paralysis.

The experiments undertaken on the nature of the cause of Marek's fowl paralysis permit the conclusion that it must be some variety of a virus because it is filtrable, glycerin-proof and capable of resisting prolonged desiccation.

NÄHRMANGELKRANKHEITEN DES GEFLÜGELS

Von Professor Dr. Oskar Seifried, *Vorstand des Institutes für Tierpathologie der Universität München, Deutschland*

Die Erforschung der Nährmangelkrankheiten des Geflügels hat entsprechend ihrer wirtschaftlichen Bedeutung beachtenswerte Fortschritte zu verzeichnen. Dies trifft namentlich für das Gebiet der Vitaminmangelkrankheiten zu.

Die Vitamin-A-Mangelkrankheit (A-Avitaminose), die im Jahre 1919 zum ersten Male in Kalifornien von Haring, Beach und Jaffa festgestellt wurde, konnte im Jahre 1928 von Seifried und Mitarbeitern auch in Deutschland ermittelt werden. Seitdem liegen Berichte über ihr Vorkommen in fast allen Kulturländern vor. Diese

Krankheit beansprucht sowohl wegen ihres seuchenhaften Auftretens, und der durch sie verursachten Verluste, als auch wegen ihrer grossen Ähnlichkeit mit der infektiösen Laryngo-Tracheitis, der catarrhalischen Form der Pockendiphtherie, sowie mit der Coryza contagiosa grösstes Interesse. Ihre weitere Erforschung hat in den letzten Jahren zu wichtigsten Ergebnissen geführt. Gewöhnlich sind junge Tiere im Alter von 3–9 Monaten besonders empfänglich. Die Erkrankungsziffern sind bisweilen sehr hoch und können in einem Bestande bis zu 90 Prozent betragen. Die Verlustziffern schwanken zwischen 20 und 30 Prozent. Das hauptsächlichste Auftreten wird im Frühjahr und Frühsommer beobachtet und zwar in solchen Beständen, denen während der Wintermonate Grünfutter (hauptsächlichste Vitamin-A-Quelle) nicht oder nur in unzureichenden Mengen zugänglich war. Die Krankheitszeichen bestehen in einer serös-schleimigen oder schleimig-eiterigen Rhinitis mit Verlegung der Nasengänge, Anschwellung der Unteraugenhöhle und in schwerer Atemnot. Fast gleichzeitig wird Keratokonjunktivitis, verbunden mit Lichtscheue und Tränenfluss und Verklebung der Augenlider beobachtet. Neben der für A-Avitaminose kennzeichnenden Xerophthalmie oder Keratomalazie in Form von weisslichen Belägen auf dem dritten Augenlid, bzw. auf der Hornhaut, finden sich ähnliche Veränderungen im Bereiche der Choanen und der Infundibularspalte sowie in der Mundschleimhaut, am Kehlkopf und im Schlunde. In diesem sind namentlich stecknadelkopfgrosse, pustulöse Bildungen von ausgesprochen weisser Farbe erwähnenswert, die sich über die ganze Schleimhaut des Schlundes erstrecken können und nicht selten in dichter Lagerung bis in den Anfangsteils des Kropfes hineinreichen. Es handelt sich dabei um stark erweiterte, mit weisslichkäsigen, ausdrückbaren Massen erfüllte Schleimdrüsen. Ähnliche Bildungen befinden sich bisweilen am Kehlkopfseingang und in der Luftröhre. Auch im Bereiche der verschiedenen Munddrüsen können solche Bildungen festgestellt werden. Seltener ist die Schleimhaut der Mundhöhle und des Schlundes, vielfach diejenige der Luftröhre und des Kehlkopfes an Stelle der Pusteln von gelbweissen, membranartigen Belägen bedeckt, die auch die Unteraugenhöhle und die Nasengänge ausfüllen können. Diesen bisher genannten, fast regelmässig auftretenden Erscheinungen gesellen sich in einem hohen Prozentsatz der Fälle solche von Seiten des zentralen und peripherischen Nervensystems hinzu. Sie bestehen nach Seifried in Unruhe, Nervosität, Schreckhaftigkeit, später in Bewusstseins- und Gleichgewichtstörungen, Erblindung, Inkoordinationserscheinungen, Ataxien, Beinschwächen, Krämpfen und Konvulsionen. Paresen und Paralysen wie bei der B_1-Avitaminose werden seltener Beobachtet. Das Auftreten dieser nervösen Symptome fällt ungefähr mit dem Erscheinen der Veränderungen am dritten Augenlide und in anderen Organen, sowie mit der Gewichtsabnahme zusammen. An sonstigen Veränderungen in den Organen der Leibeshöhle sind noch zu nennen: das häufige Auftreten von Nierengicht, seltener von Eingeweidegicht, Hodenatrophien, Entartungen des Eierstocks, Eileiter- und Bauchfellentzündungen, sowie entzündliche Zustände der Darmschleimhaut. Die genannten Krankheitszeichen und pathologisch-anatomischen Veränderungen treten bei den einzelnen Tieren in verschiedenem Grade und Umfange hervor. Bald stehen die Veränderungen in den Augen, bald diejenigen im Bereiche der oberen Atmungs- und Verdauungsorgane, bald die Erscheinungen von Seiten des peripherischen und visceralen Nervensystems im Vordergrunde des Krankheitsbildes. Das Wesen der Krankheit besteht nach den Untersuchungen von Wolbach und Howe sowie von Seifried in einer eigenartigen Atrophie und Entartung der auskleidenden Schleimhaut- und Drüsenepithelian (der Augen, der Schleimhäute der oberen Atmungs- und Verdauungswege, der Geschlechtsorgane usw.) und in deren Ersatz durch ein neugebildetes, lebhaft sich vermehrendes, mehrschichtiges, verhornendes Plattenepithel. Der gesamte Vorgang, der regelmässig zum Verlust der funktionellen Eigenschaften der Originalepithelien (Flimmerepitheltätigkeit, Sekretion von Schleim mit bakteriziden Eigenschaften) führt, ist kennzeichnend für A-Avitaminose und erklärt ausserdem die örtliche Infektionsbereitschaft, die mit diesem Vorgang regelmässig verbunden ist (Wolbach und Mitarbeiter, Seifried). Die den nervösen Erscheinungen zugrunde liegenden Veränderungen sind wesensgleich mit denjenigen bei der B-1-Avitaminose. Was den Mechanismus des ganzen Krankheitsvorganges anbetrifft, so bestehen darüber noch grosse Unklarheiten. Neuere Untersuchungen von Domagk und Dobeneck sowie von Seifried weisen aber darauf hin, dass das Vitamin-A besonders mit dem Fettstoffwechsel zusammenhängt. Nach Massgabe von Fütterungsversuchen und praktischen Erfahrungen lässt sich die Krankheit durch ausreichende Grünfütterung oder durch Zugabe von Karotten, Lebertran und sonstigen Vitamin-A-Quellen zum Futter mit Sicherheit verhüten. Tiere, bei denen die Krankheit bereits ausgebrochen ist, können durch frühzeitige Vornahme eines Futterwechsels im obigen Sinne geheilt werden. Da die verschiedensten Infektionen der oberen Luftwege nicht selten durch einen primären Vitamin-A-Mangel ausgelöst sind, können auch sie durch Vitamin-A-Gaben günstig beeinflusst werden.

Die durch Mangel des Vitamins B 1 bedingten Ausfallserscheinungen (BeriBeri) sind als Spontankrankheit selten. Am häufigsten treten sie in Geflügelbeständen auf, in denen ausschliesslich Mahlprodukte, wie Weizenmehl, Müllereiabfälle oder gekochter, geschälter Reis die Hauptnahrung der Tiere bilden. Solche Mangelfütterung führt nach etwa 20–26 Tagen zum Auftreten von ataktischen Bewegungen, ein- oder doppelseitigem Hinken, Zusammenknicken und Auseinanderspreizen der Beine, von Krämpfen und Konvulsionen und von Lähmungen der Flügel und der Beine verschiedensten Grades. Das Sensorium bleibt in den meisten Fällen frei. Die anatomische Grundlage der Lähmungen sind schwere, nur histologisch feststellbare Entartungen von Nervenzellen im Rückenmark und von Nervenfasern in peripherischen und visceralen Nerven (siehe A-Avitaminose). Das Wesen der Krankheit besteht in einer Störung des Kohlehydratstoffwechsels, wobei die Frage noch unentschieden ist, ob der Vitamin-B-1 Mangel unmittelbar auf diesen oder auf dem Umwege über innersekretorische Drüsen einwirkt. Die Krankheit kann durch Verfütterung genügender Mengen einer Vitamin-B1-Quelle verhindert und auch geheilt werden, vorausgesetzt, dass der Vitaminmangel nicht erst in einem weit fortgeschrittenen Stadium des Krankheitsgeschehens behoben wird.

Weniger wichtig ist das wasserlösliche Vitamin-C für das Geflügel. Immerhin scheint es nicht wie bisher angenommen wurde, ganz bedeutungslos zu sein. C-Avitaminose lässt sich bei jungen Hühnern experimentell in typischer Weise erzeugen. Im Vordergrunde des Krankheitsbildes stehen degenerative Veränderungen der Gefässendthelien und der Gefässwände, womit die in den verschiedenen Organen auftretenden Blutungen im Zusammenhange stehen. Auch die Knochenveränderungen treten in kennzeichnender Weise auf. Nachdem in neuerer Zeit das Wesen des sog. "weissen Fleisches" bei den verschiedenen Haustieren eine Klärung erfahren hat, und zwar in dem Sinne, dass höchstwahrscheinlich ein Vitamin-C-Mangel vorliegt, wäre Die Klärung der Frage von Wichtigkeit, ob nicht die bei Enten und Hühnern beschriebene Muskeldystrophie ebenfalls auf Vitamin-C-Mangel zurückzuführen ist.

Die Wirkungsweise des Vitamins-D ist allgemein bekannt, sodass darauf nicht näher eingegangen zu werden braucht. Es gilt als Gleichgewichtsregler im Calciumstoffwechsel, wobei es noch unklar ist, ob es unmittelbar auf die Knochensubstanz einwirkt, oder ob es seine Wirkung auf dem Umwege über die innersekretorischen Drüsen entfaltet. Ein Mangel an Vitamin-D führt jedenfalls zu mangelhafter Ca-Resorption in den wachsenden Knochen und damit zu einer Störung der enchondralen, seltener der periostalen Ossifikation mit dem bekannten klinischen und anatomischen Bilde der englischen Krankheit. Durch die Entdeckung des Vitamins-D, im besonderen durch die Möglichkeit der Aktivierung seines Provitamins durch Ultraviolette Strahlen, ist die Therapie dieser Krankheit auch beim Geflügel umwälzend beeinflusst worden. Die Verhütung der Rachitis des Geflügels ist infolgedessen heute kein Problem mehr. Weniger bekannt ist aber, dass auch Überfütterung mit grösseren Dosen von Vitamin-D bei Hühnern pathologische Veränderungen hervorrufen kann, in ähnlicher Weise, wie dies bei D-Überdosierung bei Kindern beobachtet wurde. Die Untersuchungen von Seifried und Heidegger zeigen, dass es auch bei Hühnern bei Überschuss von Vitamin-D zu hochgradiger Verkalkung der elastischen Fasern in Arterien und inneren Organen kommt. Die hochgradigsten Veränderungen dieser Art weisen Milzgefässe und Milzkapsel auf, sodass Milz- und Gefässrupturen zustandekommen, und tödliche Verblutungen sich einstellen. Auch bei Mangel an Vitamin-D bei ausgewachsenen Hühnern treten ähnliche Veränderungen auf, was darauf hinweist, dass dem Vitamin D für die Aufrechterhaltung des Kalkgleichgewichtes eine besonders wichtige Rolle zukommt.

Nach Verabreichung einer Futtermischung, die alle Ernährungsfaktoren ausser Vitamin-E enthielt, sahen Pappenheimer und Göttsch bei jungen Hühnern Ataxie, Steifheit der Beine, Tremor, Stupor, klonische Krämpfe der Beine, Krampf der Halsmuskulatur und Wackeln mit dem Kopfe auftreten. Diese Krankheitszeichen erscheinen plötzlich, gewöhnlich zwischen dem 18. und 25. Tage nach Versuchsbeginn und können tödlich enden. Im Falle der Genesung entwickeln sich die Hühner in normaler Weise. Als anatomische Grundlage für diese Krankheitszeichen können ausgesprochene Veränderungen im Kleinhirn der erkrankten Küken festgestellt werden. Sie bestehen in Oedemen, Nekrosen und Blutungen, die bereits mit blossem Auge nachgewiesen werden können. In den Kapillaren in und um diese degenerativen Herde herum finden sich häufig hyaline Thromben. Die Ursache der Krankheit ist noch nicht völlig geklärt; es erscheint sehr fraglich, ob es sich dabei um einen alleinigen Mangel von Vitamin-E handelt. Es ist besonders auffallend, dass nach Verfütterung derselben Futtermischung bei jungen Enten keinerlei Gehirnveränderungen sich entwickeln, dagegen eine generalisierte, mit schweren Lähmungen einhergehende Muskeldystrophie (Pappenheimer und Mitarbeiter). Eine enzootisch auftretende Muskeldystrophie bei jungen Enten, die anatomisch und histologisch in allen Teilen mit der von Pappenheimer beschriebenen Krankheit übereinstimmt, ist in Deutschland von Seifried und Heidegger beobachtet worden. Die Ursache ist noch unklar. Alles spricht aber dafür, dass es sich dabei um einen Nährschaden handelt. Dasselbe trifft für die von Potel beschriebene Muskeldystrophie bei jungen Hühnern zu.

Die übrigen Vitamine scheinen beim Geflügel eine weniger grosse Rolle zu spielen, oder sie sind in ihrer Wirkungsweise bei diesen Tieren noch nicht bekannt. Ein Mangel an dem Seborrhoeverhütenden Vitamin-H scheint auch bei Hühnern ein krustöses Hautexanthem mit umeschriebenen Federnausfall zur Entstehung zu bringen. Es ist durch Verabreichung einer Vitamin-H-Quelle günstig zu beeinflussen.

An sonstigen wichtigen Nährschädenkrankheiten sind noch zu nennen die Gicht beim Geflügel, deren Zustandekommen nicht immer durch zu reichliche Eiweissgaben erklärt werden kann. Veränderungen der Nieren und der Harnleiter der verschiedensten Art, sowie höchstwahrscheinlich toxische Schädigungen der Nierensubstanz begünstigen die Entstehung.

Auf zu eiweissreicher Fütterung beruht die sog. Kreuzrehe (Glage, Holst, Ogata u.a.), die vornehmlich Küken befällt, mit Krämpfen und Lähmungen einhergeht, und auf eine Erkrankung der Streckmuskeln des Kniegelenks, der Zehen und des Rückenmarks zurückzuführen ist.

Eine letzte, hier zu nennende Nährschadenerkrankung ist eine Lähmung bei ganz jungen, 8–14 Tage alten Küken. Sie ist in den letzten Jahren in den Vereinigten Staaten von Amerika, in Deutschland, und in anderen Ländern beobachtet worden (Norris, Heuser, Wilgus u.a.). Ihr Hauptsymptom ist eine maximale Krümmung der Zehen nach Innen (Faustbildung) mit Lahmgehen. Durch Verabreichung von Milchprodukten, bzw. von Hefe ist die Krankheit in günstigem Sinne zu beeinflussen, bzw. zu heilen.

Ob die von Jungherr in den Vereinigten Staaten von Amerika neuerdings beschriebene Osteopetrosis gallinariun eine Nährmangelkranheit darstellt, ist zur Zeit noch unentschieden.

ZUSAMMENFASSUNG

Die wichtigsten Nährmangelkrankheiten des Geflügels sind in Vorstehendem kurz besprochen.

Besondere Berücksichtigung haben erfahren: die A-Avitaminose, die B1-Avitaminose, die Rachitis, die Schädigungen bzw. Verkalkungen innerer Organe im Gefolge von Überdosierung mit Vitamin-D, die Nährschädenencephalomalazie (Pappenheimer und Mitarbeiter) sowie die enzootische Muskeldystrophie bei Enten und Hühnern (Seifried und Heidegger, Potel). Endlich wurden berücksichtigt Hautexantheme bei Vitamin-H-Mangel, Gicht, Glage'sche Kreuzrehe, sowie Ernährungs-Zehenverkrümmung.

Die genannten Krankheiten, soweit ihre Ursache einwandfrei feststeht, sind durch Verabreichung der fehlenden Nährstoffe, bzw. durch Änderung des Nährstoffverhältnisses in günstigem Sinne zu beeinflussen bzw. zu heilen, vorausgesetzt, dass die Behandlung in frühen Stadien des Krankheitsgeschehens erfolgt.

Die neue Erkenntnis, dass ein Mangel an Vitamin-A eine besondere örtliche Infektionsbereitschaft in den oberen Atmungs- und Verdauungswegen bedingt, ist für die Behandlung von infektiösen Erkrankungen dieser Organsysteme von Wichtigkeit. Vitamin-A Verabreichung beeinflusst nicht nur die Vitamin-A-Mangelkrankheit, sondern auch die lokale Infektion.

Von Wichtigkeit ist auch die Feststellung, dass ein Mangel an Vitamin-A eine ähnliche Wirkung auf das zentrale und peripherische Nervensystem ausübt, wie Vitamin-B 1-Mangel.

Die ursächliche Trennung der verschiedenen Nährschädenlähmungen ist auf Grund histologischer Untersuchungen möglich und ihre erfolgreiche Behandlung deshalb in grössere Nähe gerückt.

SUMMARY

The most important poultry diseases caused by malnutrition are briefly discussed.

Particular consideration was given to: A-avitaminosis, B_1-avitaminosis, rachitis, injury or calcification of inner organs due to the feeding of too much vitamin-D, cephalo-malacia due to malnutrition (Pappenheimer and collaborators) and enzootic muscular dystrophy of ducks and fowls (Seifried and Heidegger, Potel). Discussed also were exanthemas of the skin caused by vitamin-H deficiency, gout, Glage's "Kreuzrehe" and curved toes due to nutritional influences.

Where the causes of the above-named diseases have been definitely established, they may be favorably influenced through the feeding of lacking nutrients or by a change of the ratio of nutritive substances; it is necessary, however, that the diseases be treated at an early stage.

The recent experience that vitamin-A deficiency creates a particular local disposition for infection in the upper respiratory and digestive tracts is of great importance for the treatment of infectious diseases of these parts. The feeding of vitamin-A not only influences the disease caused by vitamin-A deficiency, but it also has an effect upon local infections.

Of importance is also the finding that the effect of vitamin-A deficiency upon the central and peripheral nervous system is similar to that of vitamin-B_1 deficiency.

Differentiation of deficiency diseases, with respect to their causes, may be obtained through histological investigations, which have brought us much nearer to their successful treatment.

SYMPOSIUM

FOWL LEUKOSIS

By E. L. STUBBS, *Professor of Veterinary Pathology, School of Veterinary Medicine and School of Animal Pathology, University of Pennsylvania, Philadelphia, Pennsylvania, U. S. A.*

The fundamental work of Ellerman and Bang (*1*),[1] which showed that some strains of fowl leukosis are transmissible, greatly stimulated studies in the field of leukemia, and the chicken has been much used as the experimental animal. Ellerman and Bang (*2*) used the term leukosis to include the various types of leukemia in fowls that they described. The term leukosis is used at present to include the leukemias as well as the leukemia-like diseases of fowls. Some workers use the term leukosis to include a wide variety of conditions, and in addition to erythroleukosis, myeloid leukosis, and lymphoid leukosis, which Ellerman and Bang described, include neurolymphomatosis, iritis, fowl paralysis, and various tumors. It seems most appropriate to use leukosis as a term referring to the leukemias and the leukemia-like diseases of fowls, diseases that are difficult of diagnosis without considerable study and sometimes impossible of differentiation.

Some of the strains of leukosis are transmissible, a fact that facilitates their study, whereas others have not been shown with certainty to be transmissible and are not well understood. Some strains manifest definite blood alterations, which aid in diagnosis. Other strains do not, thereby adding to the difficulties of differentiation and contributing to confusion in regard to their etiology.

Studies in this field have resulted in many different views and opinions. Some strains have been found that produce definite blood alterations that can be reproduced with ease, and when the proper conditions are supplied yield the same results at all times. Such a circumstance gives rise to the opinion that these strains are pure and have a single etiological agent.

Some strains are not so simple in character and give rise to more than one condition. This fact indicates that at least some strains that apparently have a single etiological agent can activate different conditions and can stimulate more than one type of cell to unrestricted growth.

Some strains are exceedingly complex and give rise to a great variety of conditions. It is believed by some investigators that such strains have a single etiological agent that is capable of producing a wide variety of manifestations. Others believe that these are mixed strains rather than a single strain, and that the reason a wide variety of manifestations is obtained is that such strains have several different disease-producing potentialities.

CHARACTERISTICS OF STRAIN 1

Strain 1 is apparently a pure strain and has a single etiological agent that produces leukemia under experimental conditions. This strain was described by Furth in 1930 (*3*) and in 1931 (*4*) and by Stubbs and Furth in 1931 (*5*) and has been used extensively since that time. Stubbs and Furth (*6*) have shown by controlled experiments that strain 1 produces leukemia in most of the chickens injected, and is manifested by stimulation of primitive blood cells to unrestricted growth with flooding of the circulation and collections of the same cells in the blood-forming tissues. Stubbs and Furth (*6*) obtained similar strains from natural cases that on transfer showed the same changes as those found in experimental cases. Stubbs (*7*) has shown by experimental work that the younger the chicken the greater its susceptibility, the shorter the period of incubation, and the higher the mortality. Six different breeds of chickens were tested and found to be susceptible. Other species of fowls, including guineas, turkeys, pheasants, pigeons, ducks, and geese were tested and did not become affected. One pheasant-chicken hybrid was successfully inoculated, and from this leukemic hybrid the disease was passed readily to chickens but not to pheasants.

Furth (*8*) has shown that the causative agent of strain 1 is filtrable and that it is contained in both the blood cells and plasma. The causative agent is in greater concentration in the cells than in the plasma, because infection does not succeed so often from plasma or filtrate as from cells and the period of incubation is not so uniform. Furth (*9*) found that the filtrable agent of leukosis resists drying, glycerination, and freezing. The causative agent of strain 1 resists desiccation, as reported by Stubbs (*10*). Desiccation was accomplished by withdrawing blood from an affected chicken, freezing it, and then drying it from the frozen state in vacuo over phosphorus pentoxide, sealing it, and placing it in an electric refrigerator. The desiccated blood was tested by the use of a portion resuspended in distilled water and injected into chickens at various intervals. Tests were made 2, 89, 283, 365, 442, and 932 days following desiccation, after which no further dried blood of that lot was available. Chickens became affected with leukosis at these intervals after desiccation, showing that the causative agent of this strain retains its activity in the dry state as long as 932 days.

[1] Italicized numerals in parentheses refer to Literature Cited, p. 297.

OTHER TRANSMISSIBLE STRAINS

Oberling and Guerin (*11*) described a strain that they believed produced both leukosis and sarcoma and probably carcinoma, and suggested that a mutation occurred with a substance that had an affinity for both mesodermal and ectodermal tissues. Troisier (*12*) made similar experiments with the same results. Rothe Meyer and Engelbreth-Holm (*13*) described a strain that produced leukosis and sarcoma. Stubbs and Furth (*14*) described a strain that produced leukosis and sarcoma. Jarmai (*15*) described a strain that produced small fibrosarcoma at the point of injection in fowls that did not succumb to leukosis within a short time. Such work indicates that strains of leukosis when injected intravenously produce leukosis, and when injected locally produce a tumor at the site of injection. It is believed that a tumor is more likely to occur when the material injected is composed of tissue rather than of blood.

TESTS OF STRAIN 1 FOR TUMOR PRODUCTION

Stubbs (*16*) reports several series of injections of strain 1 into chickens over a period of 2 years. The material injected was blood, liver, spleen, and bone marrow and was injected subcutaneously and intramuscularly to test the ability of this strain to produce a tumor at the site of injection. Previous experiments indicated that the causative agent of strain 1 is most concentrated in the whole blood because the greatest number of takes follow the injection of whole blood into susceptible chickens. Likewise, a higher percentage of takes results from the injection of blood cells washed free of plasma than from plasma alone, indicating that the causative agent is in close association with the blood cells. Thus it seemed that whole blood producing a high percentage of takes when injected intravenously should provide a suitable material to inject locally to test the ability of this causative agent to produce a tumor at the site of injection. Fifty-nine chickens were injected with whole blood from seven different donors, this blood being injected intramuscularly and mostly into the breast muscles. Thirty-five cases of leukosis developed, but no evidence of any tumor formation was found. Liver tissue was tested for its tumor-producing qualities because observations are recorded that, when injected locally, livers of leukotic chickens have the ability to produce leukosis. Liver-tissue suspensions were prepared by mincing leukotic liver with an equal quantity of Ringer's solution, and the injection of this suspension was made intramuscularly into the breast muscles. Fifty-two chickens were injected with this material obtained from four different donors affected with leukosis. Twenty-six cases of leukosis were produced, but there was no evidence of tumor formation at the site of injection or at any other point in any chicken. The only result produced by the local injection of such leukotic tissues was the production of leukemia similar to that found after the intravenous injection of similar materials. No evidence could be found to suggest that our strain 1 is related in any way to the production of tumors. No cases of fowl paralysis were found in this series, and there was nothing to suggest that our strain 1 is related in any way to fowl paralysis.

TUMOR-PRODUCING STRAINS

Strain 2 has been reported by Furth (*17*) as a filtrable agent that produces lymphomatosis, myelomatosis, and endothelioma, rarely with paralysis, sometimes with leukemia, and sometimes with tumor formation. Paralysis occurring in transfers of this strain is usually not associated with gross lesions but only with microscopic changes simulating paralysis. This strain does not stimulate endothelium at the site of injection but stimulates endothelium of blood vessels, and endothelioma caused by it is always associated with leukosis.

Strain 11, described by Furth (*18*), produces a sarcoma similar to the spindle-cell sarcoma of Rous and does not produce leukosis.

Strain 12, described by Furth (*19*), produces osteochondrosarcoma and leukosis. This virus produces neoplasms only when brought into contact with bone or cartilage.

Strain 13, described by Stubbs and Furth (*20*), produces sarcoma and leukosis. This strain is characterized by the formation of a sarcoma at the point of injection and the formation of endothelial neoplasms in the blood-forming organs often associated with proliferation of erythroblasts and the production of leukemia. The causative agent is filtrable and shows an affinity for connective-tissue cells and for endothelial cells of the blood-forming organs. When injected subcutaneously or intramuscularly, it forms a sarcoma at the point of injection, and when injected intravenously produces diffuse sarcomatosis of the blood-forming organs with leukemia.

Furth and Breedis (*21*) have reported extensive investigations with attempts at cultivation, in tissue culture, of viruses producing leukosis in fowls. Strain 1 remained viable in the presence of myeloblasts that apparently proliferated in symbiosis with fibroblastlike cells, so that these tissue cultures containing myeloblasts and fibroblastlike cells, when injected into chickens, produced leukosis. The inoculation of leukemic myeloblasts in liquid culture showed evidence of mitosis for at least 32 days and retained the ability to produce leukosis. Strain 2, by cultivation of the neoplastic endothelial cells, was maintained in vitro for 34 days and by cultivation of leukotic spleen was maintained for 36 days. Strain 12 was maintained in vitro for 91 days by the cultivation of the tumorlike growth produced by this virus. The cells grown resembled fibroblasts, and when these cells were injected into chickens produced both osteochondrosarcoma and leukosis. Strain 13 was maintained for 158 days in cultures of the sarcoma. However, when normal fibroblastic cells of the chicken were grown in tissue culture with the virus, the virus did not survive. Attempts were also made to cultivate strain 1 virus with sarcoma cells produced by another virus that does not stimulate primitive blood cells. In this case, strain 1 virus perished in the presence of such cells and did not produce leukosis. Doctor Furth concludes from these experiments that oncogenous viruses multiply in vitro only in the presence of cells on which they confer neoplastic properties. His findings indicate that a single virus may stimulate both primitive blood cells and fibroblastlike cells.

Furth and Breedis[2] found that the viruses of leukosis can be concentrated by high-speed centrifugalization at 29,000 r.p.m. during 2 hours, after which the supernatant fluid is often entirely inactive.

Some workers believe that leukosis is closely related to lymphomatosis and that a single cause may be followed by various types. Patterson and coworkers (*22, 23, 24*) subscribe to this opinion and assert that injection of any type may be followed by any or all of a group of manifestations. They believe that erythroid, myeloid, lymphoid, nerve, and eye types are the same. They also believe that neoplasms, as round-cell sarcoma, lymphosarcoma, lymphocytoma, and lymphatic leukemia are the same as lymphoid leukosis. They also believe that the disease in all its expressions can be transmitted by the injection of fresh material and by direct and indirect contact. Lee and coworkers (*25, 26*) hold similar views and believe that these diseases may be transmitted through the egg.

Johnson (*27, 28*) suggested hemocytoblastosis as a term to include all the various types that he also believes arise from a common source.

Emmel (*29, 30*) regards hemocytoblastosis as the primary disease and believes hemocytoblastic alteration of the blood later causes the manifestations of the various forms of leukosis and lymphomatosis. He believes the hemocytoblastosis is directly due to infection with bacterial organisms of the *Salmonella* group and most frequently associated with some type of parasitic infestation. This belief is in contrast to results obtained in earlier studies by many workers with this group of organisms and contrary to the fundamental work of Ellerman and Bang and their conception of leukosis as due to a filtrable agent. Much more experimental data must be presented before such a view can have wide acceptance.

SUMMARY

The most appropriate use of the term fowl leukosis seems to be in connection with the leukemias and leukemia-like diseases of fowls, diseases that are difficult of diagnosis without considerable study and sometimes impossible of differentiation.

Some strains are transmissible, a fact that facilitates their study, and have been described, whereas others are not transmissible with certainty and are not understood. Some strains are apparently pure and produce the same result at all times. Others are complex with apparently several disease-producing qualities.

Strain 1 is apparently a pure strain that has a single etiological agent, producing only leukemia by stimulating primitive blood cells to unrestricted growth. Transfer succeeds best by intravenous injection of whole blood but also by plasma, blood-forming tissues, and filtrates. The causative agent resists desiccation, glycerinization, and freezing. Its tumor-producing ability has been tested by intramuscular injections of whole blood and leukotic tissues without the production of tumors. Transfers of this strain did not produce paralysis over several years and in large series of chickens, and nothing was found to suggest that it is in any way related to fowl paralysis.

Strain 13 is a complex strain that produces leukemia when injected intravenously and sarcoma when injected intramuscularly. Its cause is filtrable and stimulates primitive blood cells as well as connective-tissue cells to unrestricted growth.

Tissue-culture studies of leukosis cells indicate that oncogenous viruses multiply in vitro only in the presence of cells on which they confer neoplastic properties and indicate that a single virus may stimulate both primitive blood cells and fibroblastlike cells.

The viruses of leukosis can be concentrated by high-speed centrifugalization at 29,000 r.p.m. during 2 hours, after which the supernatant fluid is often entirely inactive.

Mention is made of transmissible strains of Oberling and Guerin, Troisier, Rothe Meyer and Engelbreth-Holm, and Jarmai. Comparisons are made with tumor strains 2, 11, and 12 described by Furth.

[2] Personal communication.

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HEMOCYTOBLASTOSIS IN THE CHICKEN

By M. W. Emmel, *Veterinarian, Florida Agricultural Experiment Station, Gainesville, Florida, U. S. A.*

This paper presents a review of hemocytoblastosis as encountered in the author's study of fowl paralysis, leukemia, and allied conditions.

Hemocytoblastosis is characterized by a numerical increase or decrease in leucocytes and the presence of immature and degenerative blood cells in the peripheral circulation. Since the hematopoietic tissue of the chicken is more easily stimulated than that of other animals, hemocytoblastosis in the chicken can be induced by a number of different agents or conditions. The intravenous, intraperitoneal, or intramuscular injection of living or dead micro-organisms of the paratyphoid or typhoid groups; of freshly emulsified, desiccated, or autolyzed normal chicken tissues; of chemicals such as phenol, xylol, benzene, and many substances of carcinogenic nature, will induce hemocytoblastosis. It can be induced also by housing birds under adverse atmospheric conditions, by acute or chronic vitamin A or vitamin K deficiency, and by iron deficiency.

The fundamental nature of hemocytoblastosis, whether induced by any one of the stimuli mentioned, is that of tissue autolysis. The mechanism of tissue autolysis is dependent on two factors: (1) An intoxication factor and (2) a cell-multiplication stimulating factor. In any instance in which the original stimulus is destructive to blood cells and is sustained for varying intervals, hemocytoblastosis will result.

The degree of hemocytoblastosis is dependent on the nature, intensity, and duration of the original stimulus. However, the further progress of hemocytoblastosis after the cessation of the original stimulus is dependent on the intensity of the process, the susceptibility of the individual (which varies with age, strain, and often sex), and a number of other factors. Consequently, all degrees of hemocytoblastosis may develop from the original stimulus, which may pursue different courses in individuals and flocks after cessation of this stimulus.

Hemocytoblastosis is an entity itself in growing and laying flocks. It is characterized by a specific blood picture, shriveled, scaly, and often grayish appearing comb, lowered production in laying birds, retarded growth in growing birds, greater susceptibility to infection, and a comparatively low rate of mortality. Hemocytoblastosis of this type is caused by a mild original stimulus and results in recovery during a 2- to 4-month period.

Hemocytoblastosis also is the basic process which leads to the development of manifestations classified as "light," anemia, fowl paralysis, erythroblastic erythroleucosis, lymphatic erythroleucosis, myeloid leukemia, lymphomatosis, and leukemic lymphocytoma. In general, the development of these manifestations is dependent on an original stimulus of more severe intensity or a greater degree of susceptibility than in cases in which hemocytoblastosis develops only as an entity. Hemocytoblastosis leading to the development of these manifestations may assume one of two courses: (1) It may become a self-perpetuating process without further aid by the original stimulus, or (2) it may decline. The process of self-perpetuating tissue autolysis is a new fundamental process leading to the development of specific disease and is essential in the development of the various types of leukemia, and in the manifestations classified as "light" and anemia. Consequently, these manifestations are fatal. The hematopoietic tissue is usually completely exhausted at death. Differentiation is based on the rapidity of the process, the cell types involved, and emaciation in the case of "light."

Symptoms of fowl paralysis may occur during ascending or descending hemocytoblastosis, depending on the incubation period of the disease. Lymphomatosis and leukemic lymphocytoma become evident during descending hemocytoblastosis. In some instances the development of fowl paralysis, lymphomatosis, and leukemic lymphocytoma is so chronic that the blood picture has had an opportunity to return almost to normal.

According to the investigations of the author the occurrence of fowl paralysis, leukemia, and associated diseases under field conditions are induced by micro-organisms of the paratyphoid and typhoid groups. *Salmonella aertrycke*, *S. enteritidis*, and *S. typhimurium* are the three micro-organisms of this group which have been most commonly encountered in naturally occurring outbreaks of these diseases. The endotoxin of these micro-organisms tends to inhibit agglutination and phagocytosis in vitro, to destroy blood cells in vivo and in vitro, and is neurotoxic. Typical but transient symptoms of fowl paralysis can be induced in baby chicks by the intravenous injection of endotoxin prepared from the paratyphoid species by tryptic digestion. The repeated intravenous injection of endotoxin, however, will not induce typical fowl paralysis. Yet the injection of the micro-organism, augmented by certain quantities of a potent endotoxin, will induce a greater number of cases of fowl paralysis than when the same organism alone is injected. An endotoxin test on day-old baby chicks has been used with approximately 86 percent accuracy in determining later susceptibility to fowl paralysis. The hypothesis has been advanced that the pathological cell present in the blood stream by reason of hemocytoblastosis is deposited in the endotoxin-injured nerve tissue, resulting in nerve lesions of true fowl paralysis. In acute cases little opportunity exists for the development of macroscopic nerve lesions.

Under indoor-hen-battery conditions fowl paralysis, leukemia, and chronic hemocytoblastosis with a definite syndrome have been the causes of high rates of mortality. The associated syndrome, which consists of (1) poor body development most evident at maturity (2) spasmodic egg production and (3) molting, is directly proportional in intensity to the rate of mortality. Chronic hemocytoblastosis causes the development of symptoms already associated with hemocytoblastosis and a progressive, often rapid, emaciation which results in death. Adverse atmospheric conditions induced by inadequate ventilation are considered as associated with the development of these manifestations under indoor-hen-battery conditions. Such adverse atmospheric conditions are associated with a number of factors yet to be determined. Fowl paralysis, leukemia, and chronic hemocytoblastosis have not been encountered as yet under outdoor-hen-battery environments.

Experiments have been conducted which lead the author to believe that every indoor-hen-battery plant has a rather definite biologic saturation point determined by ventilation as related to the total population of the plant. In case the population exceeds this point mortality occurs, and in case the population is below this point no mortality from these diseases occurs. Many hen-battery operators make a practice of replacing birds lost through disease. In case the biologic saturation point is exceeded, which it usually is, adverse conditions are maintained continually. The installation of exhaust and intake fans extends the biologic saturation point but often is insufficient to eliminate entirely the adverse atmospheric conditions.

The development of the indoor-hen-battery plant manifestations requires a period of at least 4 months when the birds are raised indoors from baby chicks. When birds are raised outdoors to maturity and are then placed in the indoor battery, a few birds may develop symptoms within 6 weeks.

Birds reared in battery, broiler, and fryer plants also develop hemocytoblastosis as a result of adverse atmospheric conditions. However, under these conditions the birds are not held in the plant long enough for fowl paralysis, leukemia, or chronic hemocytoblastosis to develop. The presence of hemocytoblastosis usually is associated with retarded growth, nonuniform development, poor feathering, and susceptibility to respiratory diseases.

Experiments have shown that closed types of brooders are conducive to adverse atmospheric conditions and consequently to the development of hemocytoblastosis. It is a common practice to maintain a large number of brooders in one room. The adequate ventilation of the room is as important as the adequate ventilation of the brooder itself.

During the last several years it has been found that the blood of the day-old hen-hatched chick is in a mild state of hemocytoblastosis. It is not surprising that blood of this type is in a blastic condition, but it is considered an abnormality to find degenerative types of cells. Hen-hatched day-old poults likewise show mild hemocytoblastosis. As has been indicated previously, deficiencies of vitamin A, vitamin K, and iron have been found to induce hemocytoblastosis. The author is of the opinion that certain other nutritional deficiencies may do likewise. The presence of hemocytoblastosis in the hen-hatched baby chick indicates a nutritional deficiency in the egg. In one flock of turkeys the eggs of birds fed additional quantities of iron showed greater hatchability and the poults greater uniformity and livability than those from turkeys not receiving this supplement. However, day-old poults from turkeys fed the iron-supplemented ration still showed hemocytoblastosis. This fact indicates that a number of deficiencies are concerned. Day-old chicks from some flocks consistently showed a greater degree of hemocytoblastosis than chicks from other flocks. It is not unlikely that genetic as well as nutritional factors may be involved.

Blood studies have been made also of commercial artificially hatched day-old chicks in comparison with hen-hatched chicks of the same strain. Commercial artificially hatched chicks consistently showed more marked hemocytoblastosis than hen-hatched chicks. Chicks from certain incubators consistently showed more marked hemocytoblastosis than chicks from other incubators. Chicks too weak to emerge from the shell in commercial incubators showed still greater degrees of hemocytoblastosis than chicks of the same setting which hatched. Many of these chicks were anemic, and it appears plausible that the effects of hemocytoblastosis contributed greatly to their lowered vitality and inability to hatch properly. The presence of more marked hemocytoblastosis in artificially hatched chicks than in hen-hatched chicks indicates that artificial incubation can be improved. The hypothesis is advanced that adverse atmospheric conditions as they relate to the interior of the machine or as related to proper respiration of the developing embryo are concerned.

In case day-old chicks are brooded under suitable conditions, hemocytoblastosis will decline during the first 8 to 10 weeks of life. However, if the chicks are raised under conditions tending to maintain hemocytoblastosis, all of the symptoms, clinical evidences, and effects of hemocytoblastosis which have been previously described will be in evidence during a period that the author feels is a most important one for the development of vigorous, thrifty, mature birds.

In conclusion it may be said that the causes of hemocytoblastosis, so far as are known now, can be divided into five general groups: (1) Bacterial, (2) nutritional, (3) atmospheric, (4) genetic, and (5) experimental. The bacterial causes—organisms of the paratyphoid and typhoid groups—are related to the development of 12 different pathological manifestations classified under the general term "leucosis." Nutritional causes—vitamin A, vitamin K, iron deficiencies, and others yet unknown—have an important bearing on the hatching of hemocytoblastosis-free chicks and perhaps on hatchability and livability as well. Adverse atmospheric conditions are related not only to mortality in the indoor-hen-battery plant, but also to incubation, brooding, and management of growing stock as well. Although it may be questioned as yet that genetics technically can be related to hemocytoblastosis as a cause, it has been demonstrated beyond question that genetics is an important factor in susceptibility to hemocytoblastosis. Experimental causes are classified as the injection of tissue preparations, chemicals, and other substances which have made it possible to obtain a better understanding of the mechanism involved in hemocytoblastosis or tissue autolysis.

Thus hemocytoblastosis involves almost every phase of poultry production. The author believes that when the causes of hemocytoblastosis as they relate to this problem are thoroughly understood the mortality problem can be greatly lessened.

SUMMARY

Hemocytoblastosis is characterized by an increase or decrease in leucocytes and the presence of immature and degenerative blood cells in the peripheral circulation. It may be induced by the intravenous injection of living or dead species of the paratyphoid and typhoid groups of bacteria; of desiccated, freshly emulsified, and autolyzed homologous tissues; and of benzene, phenol, and xylol. Hemocytoblastosis may also result from the oral administration of bacteria of the paratyphoid and typhoid groups during intestinal parasitism; adverse atmospheric conditions; vitamin A, vitamin K, and iron deficiency; and the transmission agent of fowl leukemia. In addition to being an entity in adult flocks, hemocytoblastosis is a fundamental condition which may lead to the development, in the chicken, of fowl paralysis, leukemia, and allied diseases. These are most commonly caused by micro-organisms of the paratyphoid and typhoid groups in the field and by adverse atmospheric conditions in hen batteries. Hemocytoblastosis is a reversible process from which birds may recover. The significance of hemocytoblastosis in relation to its causes, as pertaining to brooding, incubation, and the breeding flock, is discussed.

UNTERSUCHUNGEN UEBER DIE UEBERTRAGBARKEIT DER GEFLUEGELLAEHME

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Den nachstehenden Untersuchungen ueber die Uebertragbarkeit der Gefluegellähme wurden die auf dem letzten Weltgeflügelkongress in Leipzig und Berlin 1936 vorgetragenen Forschungsergebnisse zugrunde gelegt. Danach galt es als wünschenswert, die Erforschung der Uebertragbarkeit dieser gefährlichen Geflügelkrankheit fortzusetzen, wobei insbesondere folgende Gesichtspunkte Berücksichtigung finden sollten:

1. Die Untersuchungen müssen die natürliche Entstehungs- und Ausbreitungsweise der Krankheit prüfen.
2. Die Versuchstiere muessen sorgfältig auf ihre Empfänglichkeit ausgewählt werden, wobei insbesondere die Konstitution und Erblichkeit der Krankheitsdisposition berücksichtigt werden müssen.
3. Neben den Versuchstieren müssen ebensoviele Kontrolltiere gehalten werden.
4. Die Versuchstiere müssen ueber lange Zeitraeume beobachtet werden.
5. Die Versuche müssen an einer genügend grossen Zahl von Tieren ausgeführt werden.

Unter Berücksichtigung dieser Gesichtspunkte wurde die Uebertragbarkeit der Geflügellähme erneut unter künstlichen und natürlichen Verhältnissen geprüft. Zu diesem Zweck wurden 340 Hühner unter verschiedenen Versuchsbedingungen gehalten und zur Hälfte künstlich durch intraperitoneale Injektion zu infizieren versucht, während die andere Hälfte der natürlichen Ansteckung mit der ersten Versuchsgruppe ausgesetzt wurde. Unter Zugrundelegung der allgemein anerkannten Erfahrung, dass eine Uebertragung der Geflügellähme nur in den ersten Lebenswochen bezw. Monaten mit einiger Aussicht auf Erfolg gelingt, wurden die Versuchstiere alle im entsprechendem Alter künstlich oder natürlich zu infizieren versucht.

Die Auswahl der Versuchstiere erfolgte unter Berücksichtigung der Tatsache, dass die Geflügellähme hauptsächlich eine Erkrankung der reinrassigen durch hohe Legeleistung ausgezeichneten Hühnerschlaege ist, während sie bei rasselosen oder Kreuzungstieren mit geringen Legeleistungen viel seltener oder gar nicht angetroffen wird. Demzufolge nahm ich als Versuchstiere eine Gruppe reinrassiger weisser Leghorns aus anerkannter Leistungszucht, die jedoch nach der Zusicherung des Besitzers frei von Geflügellähme war. Ihnen stellte ich eine zweite Gruppe von rasselosen sogenannten Bauernhühnern gegenüber, die wahllos aus einer grösseren Anzahl von Hühnerhaltungen in verschiedenen Gegenden Deutschlands aufgekauft wurden.

Die weissen Leghorns wurden nach neuzeitlichen wissenschaftlichen Gesichtspunkten intensiv auf Leistung gefüttert, während die rasselosen Bauernhühner unwissenschaftlich nach ländlich-bäuerlichen Erfahrungen gefüttert wurden.

In bestimmten Zeitabständen wurde die körperliche Entwicklung der Tiere durch Wiegen und soweit wie möglich auch die Legeleistungen geprüft. Die 2 Versuchsgruppen wurden in 2 getrennten, aber dicht beieinanderliegenden Stallungen mit ebenfalls getrennten Ausläufen gehalten und von einem gemeinsamen Tierpfleger gefüttert. Wenn die Tiere nicht, was leider bei einigen Versuchsreihen der Fall war, interkurrent vorzeitig verendeten, wurden sie mindestens 8 Monate lang beobachtet. Alle Tiere, die von der vierten Woche nach der künstlichen Uebertragung oder natürlichen Exposition verendeten oder getötet wurden, sind einer genauen histologischen Untersuchung unterzogen worden.

Neben diesen eigentlichen Versuchstieren wurde eine weitere Gruppe von 26 weissen Leghorns aus der gleichen oben erwähnten Zucht während der ganzen Versuchsdauer unter Beobachtung gestellt, jedoch nicht infiziert. Die Tiere waren in einem besonderen Stall mit eigenem Auslauf etwa 50 Meter von den anderen Versuchshühnern entfernt untergebracht und wurden von dem gleichen Tierpfleger gefüttert.

Als Infektionsstoff diente für die Versuche Gehirn, Nerven und Rückenmark von 11 Hühnern, die zu Lebzeiten Erscheinungen der Geflügellähme gezeigt hatten und an deren Nerven sowohl makroskopisch wie mikroskopisch die kennzeichnenden Veränderungen der Gefluegellähme festgestellt worden waren. Diese Hühner stammten grösstenteils aus einem Bestand, in dem die Geflügellähme seit mehreren Jahren beobachtet worden war.

VERSUCHSERGEBNISSE MIT DEN LEGHORNS

Für die Beurteilung der Versuchsergebnisse ist das Verhalten der 26 als Kontrolle beobachteten nicht infizierten Leghorns von massgeblichem Einfluss. In dieser Kontrollgruppe erkrankten und verendeten 2 Tiere offensichtlich an Geflügellähme. Weitere 4 Tiere zeigten bei ihrer Tötung nach 6 Monaten lediglich histologisch nachweisbare Veränderungen der Geflügellähme. Es wurden somit bei 22 prozent dieser Kontrolltiere Erscheinungen der Geflügellähme ermittelt.

Von den nach Abzug der interkurrent verendeten, verbliebenen 40 künstlich durch Injektion behandelten Leghorns erkrankten und verendeten 10 Tiere (25 prozent) offensichtlich an Geflügellähme. Weitere 14 Tiere (35 prozent) zeigten nach ihrer Tötung lediglich histologische Veränderungen der Geflügellähme, sodass bei insgesamt 24 Tieren (60 prozent) dieser Versuchsgruppe die Geflügellähme festgestellt werden konnte.

Von den der Kontaktinfektion ausgesetzten und nach Abzug der interkurrent verendeten, verbliebenen 45 Leghorns starben 4 Tiere (8,8 prozent) an offensichtlicher Geflügellähme, waehrend weitere 11 Tiere (24,2 prozent) nur histologisch nachweisbar erkrankt waren. Insgesamt wurden also bei 33 prozent dieser (Kontakt)-Versuchsgruppe Geflügellähme festgestellt.

Aus diesen Versuchsergebnissen darf zunächst gefolgert werden, dass die verwendeten Versuchstiere für die Geflügellähme empfänglich und daher für die Versuche geeignet waren. Angesichts der Tatsache, dass auch unter den Kontrolltieren sowohl klinische wie latente Geflügellähmefälle aufgetreten sind, erhebt sich die Frage, ob diese Tiere die Erkrankung gewissermassen in latenter Form schon mit in den Versuch gebracht haben oder ob ihnen das Agens der Geflügellähme im Laufe der 8 monatigen Beobachtungszeit infolge ungenügender Isolierung von den künstlich infizierten Versuchstieren zugetragen worden ist. Wenn auch die erste Möglichkeit nicht mit vollständiger Sicherheit trotz der entgegenlautenden Angaben des Züchters ausgeschlossen werden kann, so sprechen die weiteren Versuchsergebnisse an den Bauernhühnern doch entschieden mehr für eine Kontaktinfektion.

Aus den weiteren Beobachtungen und Versuchsergebnissen kann dann noch gefolgert werden, dass die künstliche Injektion von Geflügellähmematerial die Widerstandsfähigkeit der Versuchstiere gegen sonstige Erkrankungen erheblich herabsetzt. Denn die Zahl der interkurrenten Verluste übertraf mit 40 prozent bei den künstlich infizierten die der Kontaktinfektion ausgesetzten Tiere um 10 prozent. Ebenso geht aus den Versuchen hervor, dass Wachstum und Legetätigkeit durch die künstliche Lähmeübertragung ungünstig beeinflusst werden. Die nicht infizierte Kontrollgruppe wies mit 38,4 prozent die besten Legeleistungen auf. Ihr stand die der Kontaktinfektion ausgesetzte Gruppe mit 34,2 prozent nur wenig nach. Dagegen fiel die künstlich infizierte Gruppe mit nur 24,2 prozent Legeleistung deutlich ab.

VERSUCHSERGEBNISSE AN RASSELOSEN BAUERNHUEHNERN

Die Uebertragungsversuche an rasselosen Tieren wurden in 4 Versuchsreihen an insgesamt 214 Hühnern vorgenommen. Die bedeutend grössere Zahl der Versuchstiere wurde notwendig, weil in den aus diesen Tieren gebildeten Versuchsgruppen entgegen allen Erwartungen sehr hohe Aufzuchtverluste auftraten.

Von den überlebenden 97 Versuchstieren ist nur ein Tier offensichtlich an Geflügellähme erkrankt, während 11 weitere Tiere lediglich eine latente, nur durch histologische Untersuchung nachweisbare Geflügellähme zeigten. Insgesamt wurden somit bei 12 prozent der (überlebenden) Versuchstiere Geflügellähme festgestellt. Die Erkrankungsfälle ereigneten sich sowohl bei künstlicher wie auch natürlicher (Kontakt) Uebertragungsweise. Die Versuchsergebnisse an den Bauernhühnern sind in mehrfacher Hinsicht bedeutungsvoll:

1. Es ist ersichtlich, dass auch die rasselosen Hühner für die Geflügellähme selbst bei Kontaktinfektion empfänglich sind. Aus dem geringeren Prozentsatz klinischer wie auch latenter Erkrankungsfälle darf gefolgert werden, dass jedoch ihre Widerstandsfähigkeit gegenüber den Leghorns bedeutend grösser ist.

2. Angesichts der gelungenen künstlichen und natürlichen Uebertragung der Geflügellähme auf solche rasselosen Landhühner, von denen nicht anzunehmen ist, dass sie die Erkrankung in latenter Form schon mit in den Versuch gebracht hätten, darf gefolgert werden, dass auch die unter den viel empfänglicheren Leghorns in der Kontrollgruppe aufgetretenen Lähmefälle durch Kontakt infolge mangelhafter Isolierung der einzelnen Versuchsgruppen entstanden sind.

3. Die Unterschiede in den Erkrankungen bei den Leghorns und den Bauernhühnern sind sowohl quantitativer wie auch qualitativer Art. Die rasselosen Landhühner erkranken in viel geringerem Prozentsatz fast ausschliesslich in latenter Form. Da der wesentliche Unterschied zwischen diesen beiden Tierschlaegen in ihrer Konstitution zu suchen ist, folgere ich, dass die Körperverfassung der Tiere ein wichtiger übergeordneter Faktor ist, der sowohl das Krankheitsbild formt, wie auch die Zahl der Erkrankungsfälle bedingt.

Mit der Annahme von konstitutionellen Einfluessen bei der Entstehung der Geflügellähme steht das überaus wechselvolle Auftreten dieser Krankheit unter natürlichen Verhältnissen durchaus in Einklang. Immer wieder kann beobachtet werden, dass Tiere, die offenbar in gleicher Weise mit dem ursächlichen Agens behaftet sind oder behaftet sein müssen, in ganz verschiedener Weise an der Lähme erkranken, wenn sie durch den Handel unter verschiedene Umweltverhältnisse gebracht werden.

Aus den gelungenen Uebertragungen darf weiter gefolgert werden, dass die Geflügellähme unter der Einwirkung eines dem Körper übergeordneten und von aussen her übertragbaren ursächlichen Agens hervorgerufen wird, jedoch nicht eine reine Konstitutions- oder Ernährungskrankheit darstellt. Selbst nach den vorgenommenen Filtrationsversuchen halte ich die Annahme eines filtrierbaren Virus als Ursache oder Erreger der Geflügellähme bis auf weiteres noch für rein hypothetisch. Zur Entscheidung der Frage nach der Erregernatur bedarf es der weiteren Klaerung der Beziehungen zwischen der Geflügellähme und dem gesamten Komplex der Hühnerleukosen.

ZUSAMMENFASSUNG DER VERSUCHSERGEBNISSE

1. Es wurden künstliche und Kontaktübertragungsversuche mit Geflügellaehme an weissen Leghorns und rasselosen Bauernhühnern vorgenommen.

2. Die Versuche bestätigen die künstliche Uebertragbarkeit der Geflügellähme und sprechen für die Uebertragungsmöglichkeit durch Kontakt.

5. Während bei den weissen Leghorns sowohl klinische und pathologisch-anatomische Lähmefälle neben latenten (nur histologisch nachweisbaren) Erkrankungen durch die Uebertragung ausgelöst werden konnten, traten unter gleichen Versuchsbedingungen bei den sogenannten Bauernhühnern zahlenmaessig bedeutend weniger und nur latente Erkrankungsfälle auf.

4. Neben einem übertragbaren ursächlichen Agens unbekannter Natur bestimmen konstitutionelle Faktoren in entscheidender Weise Umfang und Form der Erkrankungsfälle.

SUMMARY

Experimental attempts to induce fowl paralysis in White Leghorns and barnyard fowl by inoculation and by direct contact are described.

The experimental results confirm the transmissibility of fowl paralysis by inoculation and speak for the possibility of transmission by contact.

In the White Leghorns both clinical and anatomic-pathological cases of fowl paralysis as well as latent cases (demonstrable only by histological methods) could be induced by transmission but in the so-called mongrel farm fowl under the same experimental conditions the resulting incidence of fowl paralysis was numerically distinctly lower and only of the latent type.

Next to the transmissible causal agent (of as yet unknown nature), the extent and direction of the disease are determined in decisive degree by constitutional factors.

SECTION 4. ECONOMICS INCLUDING MARKETING

RESEARCH IN ECONOMIC PHASES OF THE POULTRY INDUSTRY

By GORDON W. SPRAGUE, *Senior Agricultural Economist, Bureau of Agricultural Economics, Chicago, Illinois, U. S. A.*

Research relative to the production and marketing of poultry products has been conducted by many agencies and covers many subjects. Perhaps the greatest number of studies have been made by specialists in response to the need for information applicable to local production and marketing problems. These studies have been mostly by specialists whose resources rarely extended beyond the boundaries of their respective States. Although individual reports are often limited in scope, in total this research has gone a long way toward covering the general problems of production and marketing as related to local areas. This research has also provided a valuable background of source material. It also serves as a guide for projecting further inquiry relative to problems, many of which must be studied at considerable distance from the place where their existence first was noted.

Studies of the factors which influence consumer preference and demand in the larger markets have been made, but in much smaller number. These studies are very important but have not been made extensively, both because they are difficult and expensive to organize and also because the field of consumer research has presented methodological problems such as those of non-numerical classification. Recently this field is receiving more attention, with some promising studies now in progress.

Important research of another character has been done by the U. S. Department of Agriculture, as well as in many of the States, the results of which underlie the Annual Outlook statements of the Bureau of Agricultural Economics. This research is mostly in the form of price analysis. It shows the demand and supply response to price changes and traces out the sequence of relationships in such a way that conditions to come can be anticipated in the light of the current situation.

The work of the physical scientists is also important. Their discoveries in the field of production and in quality preservation have resulted in changes the economic effect of which is very far-reaching in the industry as a whole. Developments in turkey production and in the commercial production of broilers out of season are instances in point. Seasonals in egg production also appear to be slowly giving way to the efforts of production scientists, with the result that price seasonals are changing. This has an important effect on the cold storage industry by tending to reduce the amount of the carry-over of eggs from the spring season of surplus production to the season of fall scarcity.

It is apparent that much has been accomplished in fruitful research in the poultry industry. An avenue for continued and broader progress lies in the coordination of research activity to summarize the work already done and to extend the field into the central markets. By coordinating the resources of local research agencies, projects could be developed to study facilities and methods of marketing for poultry and eggs, both with respect to their efficiency in cost and their efficiency in preserving those characteristics of the product which are important in the stimulation of consumer demand. To accomplish this latter result it is necessary that consumer demand be studied further, so that its characteristics may be more accurately defined. Inasmuch as the goal of production and marketing is to be reached in consumer satisfaction, research should be directed toward the problem of presenting industry products in such a way as to minimize the difficulties which face the consumer in satisfying family preference and demand. Studies of this kind, mostly in the central markets, would serve to round out the research already done by the study of local facilities and conditions.

Problems even more difficult of solution lie in the highly seasonal and cyclical characteristics of poultry and egg production and marketing. Great progress has been made by physical scientists in evening out these seasonal characteristics of the industry through various methods of production and quality control. Little, if any, progress has yet been made in the control of the longer time cyclical variations which are equally important. Although much has been done by way of explaining their characteristics, the very widespread nature of the industry and the large number of persons participating in it makes the problem of controlling these cycles seem very difficult. A factor in the solution of these and other important economic problems of the poultry industry is the human response to dependable economic information.

In a progressive industry the factors of production and marketing are usually in a dynamic state. Activity in one phase of an industry is likely to react on other phases. Progress itself includes the concept of change. It is desirable, therefore, that resources available for research in the study of the problems of the poultry industry be directed so as to derive the greatest possible benefit for the industry and the country.

THE AMERICAN POULTRY INDUSTRY

By Roy C. Potts, *Principal Agricultural Economist, In Charge Division of Dairy and Poultry Products, United States Department of Agriculture, Washington, D. C., U. S. A.*

On behalf of the members of the Economics and Marketing Program Committee for this Congress and those contributing to this scientific program, we welcome the official delegates and the visitors of foreign countries, as well as the representatives of the poultry industry of the United States.

As stated in the objectives of this World's Poultry Congress and Exposition, we are gathered here "to stimulate interest in world poultry affairs; to pool the best and most recent knowledge concerning the poultry industry in all parts of the world; and to encourage the development of scientific research work and education in connection with the production and marketing of poultry products." With a view to realizing these objectives representatives of this and foreign countries are contributing to this program.

A brief résumé of the scope of the subjects to be presented on the Economics and Marketing Program is appropriate. The opening papers will discuss the more general economic problems of poultry and egg production—primarily in the United States. These papers will serve to focalize some of the specific economic problems of the poultry industry. These problems are important to the producers, the country buyers and processors, the distributing agencies, and the consumers. The diversified character of the poultry industry and its interdependence on many related commercial enterprises make many of these problems rather complex and for their solution the best thoughts and cooperative efforts of the industry are required. It is impossible on this occasion to discuss the almost unlimited variety of subjects which are related to the economic and marketing problems of the poultry industry. Consequently, the program has been organized and will be concerned with those phases of these problems which seem most important.

The program may be divided into four parts. First will be those papers which discuss economic problems of the individual producer in the organization of his poultry enterprise. These papers will encompass the farmer's problem of maintaining efficient production and in balancing his poultry enterprise. The second group of papers will be concerned with problems in marketing from the standpoint of private and cooperative organizations. The third group of papers will be devoted to economic aspects of certain specialized branches of the industry.

In the evolution of the poultry industry a number of specialized branches have been developed, such as the hatchery industry, the cold storage industry, and the frozen egg industry. The need of modern methods of processing and merchandising have recently come to the fore, which include such practices as the evisceration and preparation of "ready-to-cook poultry" including the use of quick-freezing methods and the packaging and merchandising of parts of poultry carcasses to prevent losses from deterioration of quality and preserve the products so that they will have their greatest food value and give greatest satisfaction when they are consumed.

Commercialization and specialization are necessary also to attain the greatest economy and highest efficiency possible in various branches of the industry. These phases of the industry will in some measure be covered by this program. There are also other phases of the poultry industry, such as the standardization and grading of poultry and eggs, which will receive consideration in papers that are to be presented. This section of this program will be concluded with a paper on "Trends in International Trade."

Another important group of economic services recognized by the program committee consists of assembling market information and statistics, the conduct of research in the interpretation of market information and surveys and investigations of economic problems of production and distribution. These services are rendered by both governmental and private agencies. Both will be discussed and evaluated in the light of the needs of the industry. One of the business uses of economic information will be illustrated in two papers which discuss methods that may be used in analyzing and interpreting statistical data in forecasting future trends and developments. In another paper a recent survey of egg consumption in the largest city of the United States will be reported.

The committee planned this program with two purposes in view—first, to obtain a discussion of some of the present economic and marketing problems of the poultry industry; and second, to point out ways for their solution. In the closing paper a plan for the development of international poultry statistics will be presented.

With these comments on the scope and nature of the program, I desire to mention some of the more general industrial and social aspects of the poultry industry of the United States.

EXTENT AND LOCATION OF POULTRY PRODUCTION IN THE UNITED STATES

The poultry industry of the United States is more widely distributed than any other agricultural enterprise. The census for 1935 reported poultry production in each of the 48 States. A total of 5,833,079 farms reported the keeping of poultry flocks and this number was 85.6 percent of the total number of farms in this country. during 1937 about 650,000,000 chickens were raised and that 233,000,000 were consumed by farm families and 384,000,000 were sold and therefore were a source of cash farm income. The contribution of chickens alone to the farm income was estimated at $140,000,000 as food for the farm family and at $244,000,000 as cash income for chickens sold.

During 1937, egg production amounted to over 3,000,000,000 dozens, or about 260 eggs for each person. Of the total egg production, 47,000,000 dozens were used for hatching on farms, and about 680,000,000 dozens were used as food for the farm household and 2,300,000,000 dozens were sold for consumption by urban population and for hatching in commercial hatcheries. The total value of chicken eggs produced was about $660,000,000. Of this amount, 24 percent represents the value of eggs consumed in farm household and 76 percent represents a direct contribution to the farm income.

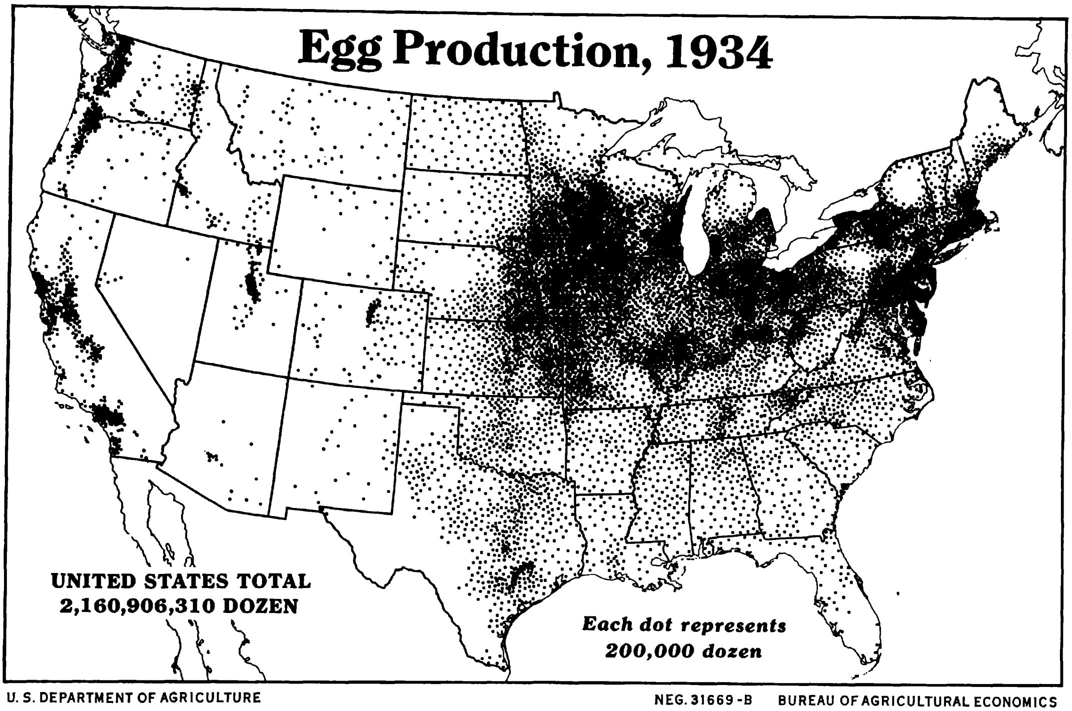


FIGURE 1.—About half of the total egg production of the United States is produced in the States comprising the region that borders Lake Michigan, where farm flocks furnish the larger part of the production. The North Atlantic Coast States comprise another important region where commercialized egg production predominates, as it also does in the scattered areas of concentrated production in the Western States.

The poultry industry consists primarily of the production of chickens and eggs, although turkey production is very important, particularly in certain sections, and geese, ducks, guinea fowl, and pigeons also are important in the order named. Figure 1 shows the distribution of chicken and egg production according to the census of 1935, and Figure 2 shows the distribution of the production of turkeys.

SIZE AND INCOME OF THE POULTRY INDUSTRY

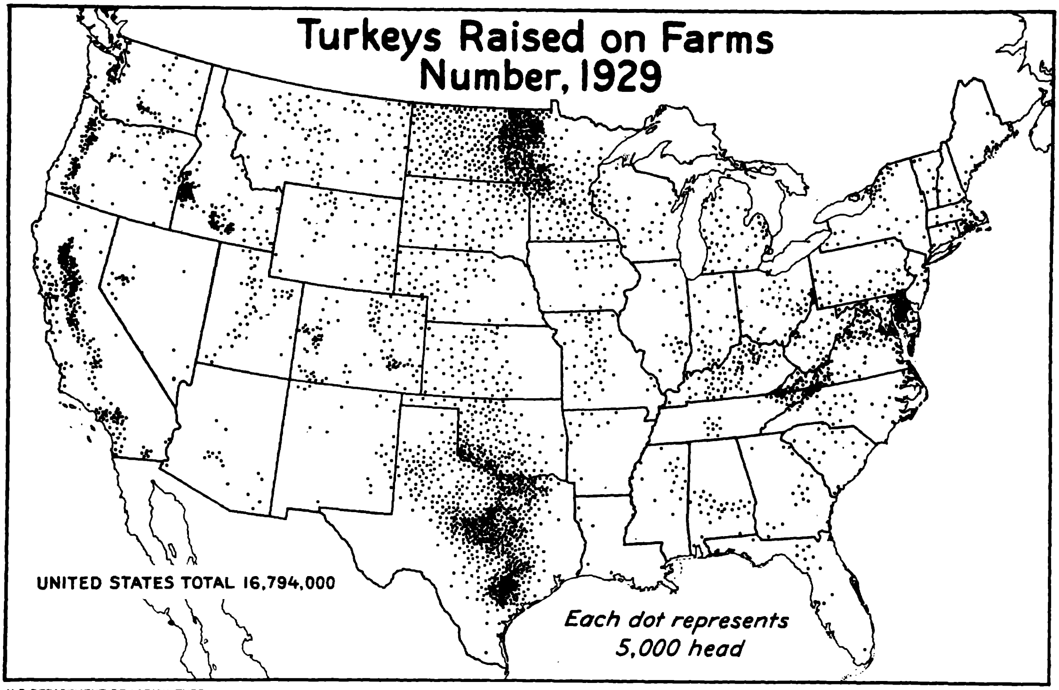
The latest estimates indicate a total of 387,251,000 chickens on farms on January 1, 1937. Of this number 71.5 percent were laying hens and pullets. These estimates also indicate that

Taken as a whole, both eggs and poultry, but excluding all types of poultry other than domestic chickens, the poultry industry returned a gross income of about $1,000,000,000, compared with the gross annual farm income *for all products* in the United States for the year 1937 of approximately $8,000,000,000. The income derived from the sale and farm use of poultry and poultry products amounted to about 12 percent of the total farm income. This is highly significant, for the poultry industry to that extent directly contributed to the happiness and security of a very large segment of the entire rural population. If this were the only economic and social value of the poultry industry, it would, in itself, afford a challenge to the best thought efforts and cooperation of everyone connected with this industry.

INDUSTRIES ALLIED TO THE POULTRY INDUSTRY

An industry as extensive, diversified, and commercialized, with a high degree of specialization such as is found in the poultry industry, necessarily, in this day of specialization and modern economic progress, calls into being, and in many ways is dependent upon, other lines of industry, which become allied to the poultry industry in one way or another. It would be extremely difficult, if not impossible, to estimate the total number of people engaged in these allied industries and to apprise the money value of the services which they daily contribute to the poultry industry. Obviously, the capital invested in these industries is very large. It will not be possible here to discuss the extent or the importance of each of these allied industries. However, their importance to the poultry industry will be apparent by the mention of some of them without reference, however, to their order of importance.

(1) Poultry hatching, brooding, and feeding equipment.
(2) Poultry killing, dressing, grading, packing, processing, shipping, and retailing equipment.
(3) Poultry and egg packing plants, both rural and urban, which include equipment for the eviscerating and freezing of poultry, and the breaking, drying, and freezing of eggs.
(4) Poultry canning plants and equipment.
(5) Transportation equipment and facilities by railroad and motor truck.
(6) Refrigeration equipment and cold storage warehouses.
(7) Heating, ventilating, and air conditioning equipment.
(8) Packing cases for eggs and poultry, egg cartons, etc.
(9) Poultry remedies, insecticides, chemicals, etc.



U. S. DEPARTMENT OF AGRICULTURE NEG. 24966-B BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 2.—While turkeys are raised to some extent in nearly all parts of the United States, the industry is largely concentrated in those areas where climatic conditions and feed supplies are peculiarly favorable to range production. Outside of these areas, until recent years, production has been largely confined to small farm flocks. With the adoption of modern production methods, commercial hatching in incubators, use of brooding houses, and confinement or semi-confinement under range conditions, the commercial production of large flocks of turkeys is increasing in the general farming sections.

(10) Products of the paper, lumber, paint, and sheet metal industries.
(11) Poultry feed manufacturing plants, warehouses, and distributing facilities.
(12) Advertising, sales, and distribution services.
(13) Personnel and facilities employed in research, extension and educational work.

THE INDUSTRY'S PLACE IN NATIONAL ECONOMY

The ramifications and magnitude of the poultry industry of the United States are inextricably interwoven into the well-being of the whole nation. It not only produces a money income to approximately five million or more farm families, but it furnishes employment indirectly to a very large number of urban people who render services that are essential for the efficient and economical production and marketing of this large volume of food products of the poultry industry. It follows, therefore, that when conditions within the poultry industry are such as to give a considerable amount of prosperity to the producers of poultry and poultry products, the demand from this industry for goods and services produced by others flows more freely and is reflected to all agencies and human activities that produce the products which farmers buy. It also follows that during prosperous times these service or allied industries are also more likely to be prosperous. It is, therefore, very much worth while at this Seventh World's Poultry Congress that we discuss thoughtfully and seriously the economic and marketing problems of this industry and ways whereby these problems may be solved. Such discussion is always desirable, for it may actually produce results that reach far beyond the boundaries of the poultry industry, and thereby benefit the great masses of our people who are not directly a part of this great and important industry.

The progress and prosperity of an industry, as well as of all the peoples of all nations, are dependent upon the thought and action of its leaders and the sympathetic cooperation of the masses of people of which the nation is comprised.

This program affords an opportunity for the representative leaders of the poultry industry of all nations who are assembled here at this World's Poultry Congress to think and act together, and to discuss together the economic and marketing problems of this industry. As I am the first speaker to appear on this program, I take the liberty to express the thought that we shall individually, severally, and as the representatives of our nations, be benefited and profit from this program in proportion as we think and cooperate together. And as we banish selfishness, greed, and force from our thoughts and become humble, thoughtful, and cooperate one with another we will promote peace, happiness, and prosperity among all the people of all nations represented here at this Congress.

SUMMARY

This paper is an introduction to the program and gives an indication of its organization and the relationship of the papers to be presented to each other and to the industry. It then discusses the size and importance of the poultry industry in the United States.

The poultry industry furnishes the population of the United States with an important part of its food supply and is the source of an important proportion of farm income. Because of its size, diversification, and commercial aspects, the poultry industry has given rise to a great many subsidiary enterprises, the existence of which cause the effect of prosperity or depression in the poultry industry to extend far beyond the limits of farm poultry production. It is therefore worth while that the economic and marketing problems of this industry be given serious consideration.

FACTORS AFFECTING PROFITS ON COMMERCIAL POULTRY FARMS

By E. G. Misner, *Professor of Farm Management, Cornell University, Ithaca, New York, U. S. A.*

Many factors affect the commercial poultry keeper's profits. Some of these are beyond his control, others are, to some extent, within his control. This paper discusses some of these factors based on data from experiment station publications.[1]

The general price level and the degree of its stability, the total supply of and total demand for poultry products, and ratios of the costs of important items in production to prices received for the products sold are the most important factors outside of the commercial poultry keeper's control which affect his profits.

[1] Factors influencing the profitable feeding of poultry, by Frank W. Brumley. Mimeographed. Florida State College of Agriculture, Feb. 1931.

Cost and efficiency in commercial egg production in Oregon, by H. D. Scudder, A. S. Burrier, A. G. Lunn, and F. L. Knowlton. Oregon Agricultural Experiment Station Bulletin 287, June, 1931.

A statistical study of commercial egg production in Delaware by R. O. Bausman. Delaware Agricultural Experiment Station Bulletin 202, Aug., 1936.

Economic studies of poultry farming in New York. I. Commercial poultry farms, 1926, 1929, 1930, 1931, 1932, 1933, by E. G. Misner and A. T. M. Lee. Cornell University Agricultural Experiment Station Bulletin 684, Dec., 1937.

There are several features of the organization of a poultry farm which are subject to the poultryman's control and which have an important influence on the profits of the individual operator.

It is the purpose of this paper to give consideration to some of these poultry farm organization factors and their relation to the labor income of poultry farmers in New York.

Labor income is the pay which the farmer receives for his labor and management in addition to 5 percent on the capital employed, the use of a dwelling, farm products to use in the house and other privileges which go with the running of one's own business. The value of all privileges and products and the use of a dwelling, of course, increase the labor income somewhat. The labor income does not express returns per unit of area or per bird; rather it reduces the profits of the business to terms of wages to the operator after a reasonable rate of interest has been deducted on the value of all of the capital used in the business.

SIZE OF BUSINESS

The size of the business operated has much to do with profits. A large business permits both greater losses in bad years and larger profits in good years than a small business. Some of the ways of measuring the size of the business on a poultry farm are: The number of layers, the amount of capital employed, and the total production in dozens of eggs.

In a study of 600 accounts on New York poultry farms for the five years, 1929–1933, the operator's labor income increased $95 for each additional 100 hens kept, $41 for each additional $1,000 in capital employed or $85 for each additional 1,000 dozens of eggs produced on the farm. The averages by measures of size are shown in table 1.

When conditions are favorable for profits in commercial poultry farming, the addition of a full one-man business to a one-man business increases the labor income of the operator. However, unless conditions are favorable, it may decrease his labor income. The point often forgotten about the principle of size of business and its influence on profits is that losses are increased in unfavorable times just as well as profits are increased under favorable conditions by additional size of business. When a one-man business is reached, it is necessary to put on another full one-man complement in order to make additional birds profitable. Many poultry farms that do not have enough birds for a full two-man business, regularly employ help. Such farms are not as profitable as one-man businesses.

Of the New York poultry farms studied, 73 percent kept less than 1500 layers, 56 percent employed less than $15,000 capital, and 60 percent produced less than 14,000 dozens of eggs for the year. For efficient operation, an average number of more than 1,500 birds should be kept with an annual egg production of 18,000 dozens of eggs or more. Such a favorable size of business should be provided with as little capital as necessary.

How far it is profitable to expand a poultry farm business depends primarily on the rate of egg production per hen a particular poultryman is capable of obtaining.

EGG PRODUCTION PER BIRD

The number of eggs laid per hen is one of the most important factors in determining profit on the commercial poultry farm. The average layer on what might be called a commercial plant produces about 12 dozens of eggs per year. Of New York poultry farms studied, 71 percent obtained less than 160 eggs per hen, and 6 percent obtained less than 100 eggs per hen. The relationships are shown in table 2.

TABLE 1.—*Relation of the size of business to the labor income and the cost of producing eggs per dozen (600 accounts), New York commercial poultry farms, 1929–33*

Measure	Small businesses	Average businesses	Large businesses
Number of layers:			
Number of layers	524	894	1,979
Labor income (dollars)	435	851	1,816
Cost of eggs per dozen (cents)	34.8	33.3	33.0
Capital:			
Capital (dollars)	8,568	14,738	31,321
Labor income (dollars)	862	1,065	1,800
Cost of eggs per dozen (cents)	31.0	34.2	35.2
Dozens of eggs produced:			
Dozens of eggs produced per farm	7,416	14,028	30,340
Labor income (dollars)	333	1,265	2,287

TABLE 2.—*Relation of eggs produced per hen to labor income and cost of production, New York commercial poultry farms, 1926 and 1929–33*

[Averages for 753 accounts in the 6 years taken as 100 percent]

Eggs per hen	Labor income on—		Cost of eggs on—	
	Farms selling chicks	Farms not selling chicks	Farms selling chicks	Farms not selling chicks
60	92	85	126	138
80	96	93	113	119
100	100	100	100	100
120	104	107	87	81
140	108	115	74	62

More labor is required, more feed is required, depreciation is greater and other costs are higher per unit of product when the rate of production is low. On commercial poultry farms in New York, for a 5-year period, each additional dozen of eggs produced per bird was accompanied by an increase of $176 in labor income. The amount which the additional production per bird may contribute to the operator's labor income is dependent upon the size of the flock, as well as upon the price of feed and the price received for eggs. The rate of production is only one of the important management problems on a commercial poultry farm, but it is an exceedingly difficult one.

DIVERSITY OF THE POULTRY ENTERPRISE

The combination of a hatchery business and the accompanying sales of chicks with the market egg business results in a higher return to the poultryman than does market egg production alone. As a 5-year average on New York farms, a 60 percent larger labor income resulted on farms selling chicks than on those not selling chicks. In order to sell chicks, it is necessary to keep a large number of old birds. This lowers the rate of egg production per bird, but is more than offset by the profits made from chick sales. A specialized hatchery business may prove more profitable than a combination of market eggs and chicks, if both of those sources of income are small, but specialized hatcheries also follow the principle of diversification by selling different breeds and marketing throughout the season.

TABLE 3.—*Relation of efficiency in man labor and production to labor income and the cost of producing eggs, on New York commercial poultry farms, 1929–33*

Measure	Farms with labor efficiency		
	Low	Average	High
Number of birds per man:			
Number of birds per man	372	700	1,264
Labor income (dollars)	650	1,328	1,926
Cost of eggs per dozen (cents)	35.2	33.2	31.0
Dozens of eggs produced per man:			
Dozens of eggs produced per man	4,314	7,556	13,104
Labor income (dollars)	606	1,154	1,959
Cost of eggs per dozen (cents)	37.7	33.3	29.8
Gross income per man:			
Gross income per man (dollars)	2,578	4,188	6,126
Labor income (dollars)	440	1,354	2,884
Cost of eggs per dozen (cents)	34.0	33.3	32.3

LABOR EFFICIENCY

Labor efficiency may be measured by number of dozens of eggs produced per man, by the number of birds cared for per man, or by the gross income per man. Any situation contributing toward an increase in any of these factors per man employed results in a higher labor income to the poultry farmer. For good labor efficiency, 10,000 dozens or more of eggs should be produced per man equivalent of all labor on the poultry farm. If the number of birds is 1,000 or more, at the average rate of production found on commercial poultry farms, and one man does the work, this rate of labor accomplishment will result. (See also table 3.)

The gross income per man depends upon the price received for the eggs as well as on the amount of production per man; therefore it is not so good a measure of efficiency as number of birds or total production per man.

On the New York farms previously mentioned, an increase of 100 in the number of birds per man was accompanied by an increase of $143 in the labor income; an increase of 1,000 in the dozens of eggs produced per man by an increase of $154 in the labor income; and an increase of $100 in the gross income per man by an increase of $69 in the labor income.

OTHER FACTORS

The percentage lay obtained in the months October to December, when eggs are relatively high in price, has an important influence on profits. On New York farms, for each unit increase in the percentage lay in these months, the labor income increased $51.

TABLE 4.—*Relation of number of important business factors as good as, or better than, the average to labor income, on New York commercial poultry farms, 1929–33*

Number of factors average or better	Records	Layers	Birds per man	Eggs per hen	Proportion of lay in October–December	Proportion of mortality, beginning number	Cost of eggs	Labor income
	Number	*Number*	*Number*	*Number*	*Percent*	*Percent*	*Cents*	*Dollars*
Farms selling chicks								
None	18	943	477	128	16.0	25.9	39.9	366
One	56	982	523	125	17.8	19.9	41.0	639
Two	80	1,343	694	144	21.8	22.3	34.9	995
Three	93	1,655	740	148	26.6	17.7	33.1	1,773
Four	42	2,003	918	155	28.2	16.9	32.1	2,424
Five	13	2,698	958	166	28.3	14.8	29.8	4,912
	302	1,521	714	144	23.4	19.7	35.0	1,514
Farms not selling chicks								
None	21	736	489	117	18.9	29.7	43.8	62
One	54	816	515	127	19.3	19.8	36.3	373
Two	76	1,035	634	148	23.6	19.4	31.1	723
Three	93	1,156	736	157	29.4	15.6	29.9	1,051
Four	39	1,562	888	161	32.7	19.0	27.8	1,623
Five	13	2,023	1,166	178	34.8	12.8	25.8	2,923
	296	1,139	691	148	26.0	18.6	31.8	945

The rate of mortality of the laying flock is also important. On New York farms, the operator's labor income decreased about $1 for each additional bird that died.

COMBINATION OF FACTORS

Since each of the previously discussed factors is important in determining the success of the business, it follows that the poultryman who has a large flock, a large number of fowls per man, obtains good egg production with a high rate of production in the October–December period, and loses less than the average number of birds, is in position to make a favorable labor income. Less than 5 percent of the New York farms studied were as good as the average in all these respects. These operators did well financially. (See table 4.)

THE COST OF PRODUCING EGGS

The cost of producing eggs is another measure of the success of the poultry enterprise. Many factors contribute to the total cost of producing eggs. The costs are feed, litter, human labor, horse labor, use of automobile and truck, use of land, use of buildings, use of equipment, interest on the laying flock, depreciation on the laying flock, and miscellaneous items. From these items of cost it is necessary to deduct the value of the manure and the value of miscellaneous receipts in order to arrive at the net cost of producing eggs.

Feed used per dozen eggs.—The dollar cost of producing eggs varies markedly between years and among farms. The cost of producing eggs in terms of basic quantities of feed and labor are less variable than the dollar cost and hence serves a more useful purpose than dollar data. The results of many studies of surveys of commercial poultry farms, as well as the results of egg laying contests, furnish data as to the feed required to produce a dozen of eggs.

Under average conditions for commercial-flock production, it appears that about 7 pounds of feed are required to produce one dozen of eggs, on a yearly basis, when the average production for the year is 40 percent; that is, when a hen lays about 12 dozens of eggs a year. In laying tests in New York in 1936, the amount of feed required averaged 6.0 pounds per dozen of eggs for Leghorns and 6.6 for birds of heavy breeds.

Variation in feed used according to production.—The quantities of feed required per dozen of eggs varies according to the rate of production. It appears that the feed requirements, per dozen of eggs produced, decrease about 40 percent as much as the percentage increase in production when comparing low with high producing birds.

For the period 1929–33, on farms that had a low cost of producing eggs (averaging 27.6 cents per dozen) the labor income was $1559. On farms with about average cost of production (39.0 cents per dozen) the labor income was $950, while on farms with high costs (averaging 53.3 cents per dozen) the labor income was $280.

Under conditions which prevailed from 1929 to 1933, the proportion of the total cost of egg production represented by the cost of the feed was about 45 percent on Eastern commercial egg farms.[2] Little information is available for later years, but probably it would not differ greatly from this proportion.

[2] See bulletins listed under footnote 1.

In commercial poultry flocks, about 2 hours of labor were required by the laying flock, annually, per bird. This amounts to about 0.17 hour per dozen of eggs produced.

The feed and labor together represent about two-thirds of the cost of producing eggs. Depreciation on the laying flock amounts to another 18 percent of the cost of production. The three items, feed, labor, and depreciation on layers amount to something over four-fifths of the net cost of producing a dozen of eggs.

Approximation of the cost of producing eggs.—The cost of producing eggs for the year for birds producing about 12 dozens annually may be approximately computed by the formula:

$$\frac{7.0 \text{ pounds of feed} \times \text{price of feed}}{45} \times 100$$

The cost of producing eggs is a simple expression of the degree of adjustment attained by the poultryman in size of business, rate of production per bird, and efficiency in the use of labor and capital. A balance of these factors is necessary for low costs, and when costs are low the profits in poultry keeping are likely to be relatively good.

SUMMARY

Many factors affect the profits on commercial poultry farms. The general price level and its relative stability, the total supply of and demand for poultry products, and the ratios of costs of products to prices, are factors largely outside of the commercial poultryman's control. Some factors subject to control are: Size of business, egg production per bird, diversity of the poultry enterprise, labor efficiency, the percentage of lay obtained in the fall, and the rate of mortality of the laying flock.

The size of a poultry farm business is measurable by the number of layers, the capital employed, and the total egg production. How far it is best to expand depends primarily on the number of eggs laid per hen. The amount by which additional production per bird may increase the income is dependent on size of flock, the price of feed, and the price of eggs. Diversifying the enterprise by combining the sale of chicks with market egg production usually results in a higher labor income than does market egg production alone. Any situation which increases the number of birds cared for, the number of eggs produced, or the gross income, per man employed is reflected in a higher total labor income.

Since the cost of producing eggs is largely an expression of a balance in adjustment of the factors mentioned above, the paper indicates some of the results of surveys of commercial poultry farms, including a formula for computing the approximate cost of producing eggs.

THE PLACE OF THE POULTRY ENTERPRISE IN THE (CORN BELT) FARM BUSINESS[1]

By L. G. ALLBAUGH, *Associate Professor Farm Management, Iowa State College, Ames, Iowa*

In contrast to the specialized commercial type of poultry production in New York, New Jersey, California, and other Atlantic and Pacific Sea Coast States, poultry and egg production in the Midwest and Corn Belt area may be characterized as a more or less important supplementary or sideline enterprise in the farm business economy. This is especially true in Iowa, the largest poultry and egg producing State in the Union. Although 93 percent of Iowa farmers produce some poultry and eggs, there are very few specialized commercial poultry farms of 500 or more hens in the flock. The same situation is found in the other Midwest States except for scattered farms near large consuming centers.

With the exception of a few specialized poultry and turkey farms, the place of the poultry enterprise in the Corn Belt farm business cannot be described in the same terms as presented by Dr. E. G. Misner of New York. While some of the factors affecting poultry profits may be universal (such as egg production per hen, mortality, etc.), others such as size of flock have little if any application to many Corn Belt farms. The Corn Belt farmer is interested in total business profits—not in poultry profits, alone.

COMMERCIAL VS. FARM FLOCK PRODUCTION

In New York, which may be assumed to be fairly characteristic of the Seaboard States, the most important type of poultry enterprise is really a complete commercialized business upon which the farm operator is almost entirely dependent for his income. This business actually consists of several individual enterprises, such as custom hatching, sale of baby chicks, broiler, fryer, roaster, breeding stock, and egg production. Some of these individual enterprises are added to reduce overhead costs and give diversification to a highly specialized business.

These various enterprises within the larger poultry business have their competitive, complementary, supplementary, and joint cost relationships in the use of land, labor, capital, buildings, equipment, and management the same as enterprises in any other business. In fact, these same comparative advantage relationships are found in the Corn Belt farm business but they are of most importance in studying the whole poultry enterprise in relation to the hog, dairy, beef, sheep, and various crop enterprises, rather than a detailed study within the poultry enterprise itself. Consequently, the Corn Belt farmer has as much or more difficulty in determining the relative profitability of the poultry enterprise in his 8- or 10-enterprise business as would the New York commercial producer between his different types of poultry production. There are too many joint cost, complementary, and supplementary relationships (to say nothing of waste feeds and uneconomic family labor) to make fine distinctions as to the profit from a single enterprise.

It has been stated that most Corn Belt farmers lose money on their oats and poultry but they lose more money on their whole farm business if they do not produce some of each—over a period of years. For this reason, many of the Midwest poultry studies conducted in the same manner as the specialized commercial poultry studies of the Eastern States have resulted in wrong conclusions and confusion. There is real merit in studying feed costs (physical and economic) and physical quantities of labor.

But how much should be charged for the labor of the wife and children, who would otherwise add nothing to the farm income? What charge should be made for buildings already owned and repaired by others and which would not be used otherwise? How much should be charged for farm raised waste feeds? These and many other difficulties in allocating joint costs for operator and family labor, buildings, etc., make most financial cost per unit studies lack validity in the Midwest. Dollar and cents figures on cost per dozen of eggs or per hen for Corn Belt farms do more to keep the professors busy exercising their minds and pencils than in helping farmers decide how to make the poultry enterprise add to the profit of the whole farm business.

On commercial poultry farms a large percentage of the costs are cash, particularly the feed, a large share (or all) of the labor and some of the equipment. In such an enterprise, these costs can be identified with the product produced. In contrast, "farm flock" production in Iowa and the Midwest is characterized by (1) the use of farm grown feeds (usually one-half or more); (2) unpaid family labor (labor of wife and children not converted into cash otherwise) and (3) a minimum of cash equipment costs.

TYPES OF "FARM FLOCK" POULTRY PRODUCTION

But the "farm flock" characterization of Corn Belt poultry production needs further clarification. "Farm flock" may be reduced to its component parts by more descriptive terms, as follows:

I. *Table use or backyard flocks*—to produce eggs and meat for home consumption.
II. *Pin money flocks*—in addition to home use to supply spending money for the farm wife or young children.

[1] Journal Paper No. J-644 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project No. 521.

III. *Grocery bill flocks*—to supply eggs and poultry in quantities sufficient to pay all or most of the grocery bills with eggs traded at local grocery stores and little attention paid to quality or market value.

IV. *Business enterprise flock*—an important enterprise placed on a business basis with other farm enterprises; (a) wife or older children in charge of 200 to 350 hens because of special income desired, or (b) farm operator taking charge, as one of several livestock enterprises to be managed. Assistance of other family members given during cropping season.

To visualize these different types of farm flocks, a somewhat arbitrary division as to size of flock and cash income is indicated in table 1. This is done with a full realization that there is considerable overlapping and much opportunity for disagreement.

While detailed statistics are not available, 1935 census data indicate that types II and III would constitute 70 to 80 percent of the farm flocks in Iowa (averaging 132 hens) and also the Midwest (averaging 90 hens). In New York, it would seem that types I and IV would make up 70 to 80 percent of the farm flocks and would be generously supplemented by commercial poultry producers.

TABLE 1.—*Types of poultry "farm flocks" common to Corn Belt farms*

Type	Number of hens	Cash income
I. Table use	10-50	None
II. Pin money	50-100	$25-$100
III. Grocery bill	100-200	100- 250
IV. Business enterprise	200-500	250-1200

DIFFERENCES IN FARM FLOCK TYPE REFLECT DIFFERENCES IN RESOURCES OF INDIVIDUAL FARM FAMILIES

A point sometimes lost sight of is that within the Midwest States most farmers and their wives consider all four types of "farm flocks" as alternatives at various stages in their family life cycle. At some time in their farming experience each family may logically (and with a true economic sense) produce poultry under each of these type characterizations. This is due to the fact that each type of production must be and is considered in the light of varying degrees of experience, ability, likes, tenure security, wealth accumulation, amounts of capital and credit, buildings and equipment, farm acreage, relative efficiency of competing enterprises and quantities and types of available labor, and marketing opportunities.

As an illustration of how a single farm family may attempt to utilize varying resources in the poultry enterprise, we find young families with no children, a small amount of capital and insecure tenure looking to a size of flock to fit available farm buildings and placing the emphasis on meat production when desiring to expand income. During the child bearing period, the size of the farm poultry flock will, in many cases, be reduced to the "table use" size and gradually expand to the "pin money" size. As the children become old enough to assist and grocery bills mount, the size of the flock is increased to trade out the grocery bill at the store. If the wife or children show special ability with the poultry the family is likely to treat it on a business enterprise basis and give it due consideration in planning expenses and income. Then if a business depression suddenly appears and poultry and egg prices drop less relative to hogs and cattle the operator may become interested in the enterprise as of equal importance with his hogs and cattle. However, if the farm has a major dairy enterprise, which rather fully utilizes the operator labor, supervision only may be given the poultry with assistance from other members of the family.

But in general, the poultry enterprise is still considered the "wife and small children" enterprise on Corn Belt farms. It is the only source of definitely allocated income made available to these people in many families. As 4-H club work and Future Farmer activities interest farm boys and girls in hogs, cattle, and sheep as sources of individual income, and as families make out more definite plans for family income and expenditures, and as farm women continue to retreat from the farm business to the farm home, the poultry enterprise will undoubtedly lose much of its "pin money" and "grocery bill" aspects and take on more of the "table use" or "business enterprise" aspects. Poultry diseases, changing housing facilities and marketing developments are also leading to the need of increased skills and abilities and will encourage the development of these last mentioned types of farm flock production and definitely encourage commercial poultry production.

TABLE 2.—*Gross returns per $100 feed fed to various enterprises*

Year	Poultry	Hogs	Dairy	Beef feeders	General purpose cattle
1932	$187	$146	$90	....	$109
1933	204	130	112	$80	94
1934	197	115	99	115	94
1935	172	166	142	152	151
1936	144	144	128	87	93
1937	137	114	121	115	101
1938	202	200	162	157	140
Average	178	145	122	117	112

Iowa Farm Business Association Reports, 1932-1938.

IMPORTANT ECONOMIC REASONS FOR FARM FLOCK PRODUCTION

Farm records kept by farm record cooperators in various parts of Iowa during the last 7 years clearly indicate that poultry flocks (even with present inefficient methods) give a higher return for $100 worth of feed fed than any other class of livestock. (Table 2 and figure 2.)

Of course the advantage varies as price conditions change but poultry and egg prices have been relatively low during the past year and yet on these farms poultry gave slightly higher feed returns for 1938 than its next competitor, hogs. However, relative gross feed returns alone do not determine the combination of enterprises in the individual Corn Belt farm. Otherwise, more than the usual 5 to 13 percent of the Iowa farm income might be expected from poultry and eggs. The size of an individual enterprise is also partially determined by the kind and quantity of available capital and labor.

Poultry, even more than the dairy enterprise, is included in many farm businesses because it utilizes certain kinds of family labor which would not add to the family income otherwise. This is particularly true of the labor of the farm wife and small children and increasingly of farm girls. Custom changes are rapidly driving this kind of help from the fields and the dairy barns. As a result the poultry enterprise in the Corn Belt is largely limited in size to the amount of this kind of family labor available.

Most Corn Belt farms have some kind of shelter which can be used for poultry. This forms a natural incentive for farm families to keep a sufficiently large flock to make full use of building resources at hand. In fact, most Corn Belt farms tend to overcrowd their flocks. With the development of movable equipment and less expensive summer shelter, tenant families with special abilities have been able to increase total poultry output more in keeping with their individual capacity and efficiency. Where some buildings are already available, little capital is needed to start in poultry production on a small scale. It is when large units and new buildings are required that cash costs and capital outlays act as deterrents.

Perhaps the most important reason for the poultry enterprise being found on most Iowa and Corn Belt farms is the relative stability of poultry and egg prices during the depression periods. This is clearly indicated by the figures from the records of one of our Iowa 10-year farm record cooperators, who is an exceptionally good hog producer. (Table 3 and figure 2.)

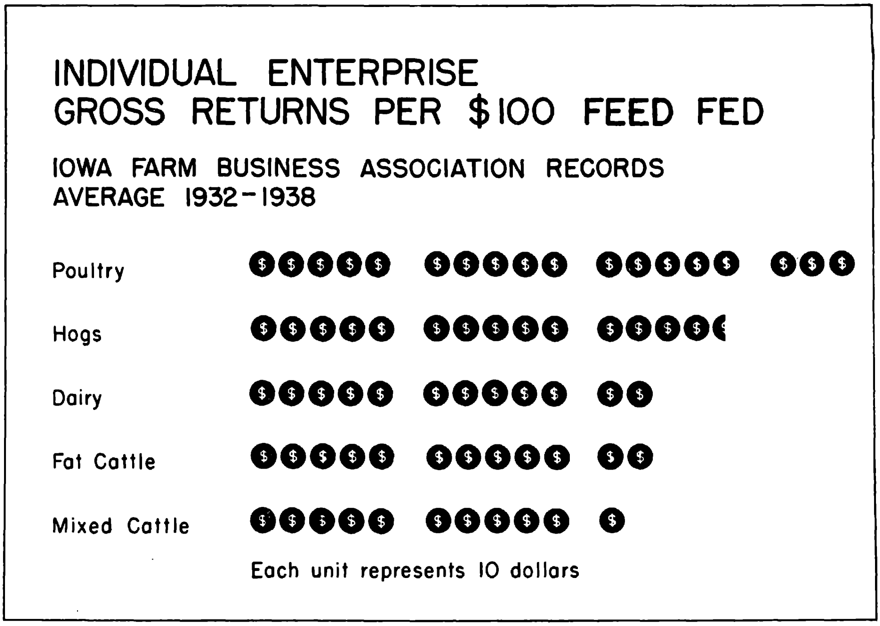


FIGURE 1.—Over the 7-year period, these farmers got a higher average return for feed from poultry than from hogs but in 3 of ten years (1935, 1936 and 1938) the differences were very small.

From the table and figure for the same farm it will be noted that with about the same organization of enterprises during the depression as in 1929 the poultry income had increased from 10 percent to 18 percent of total cash income, or almost double. This indicates the need of a depression buffer in the form of dairy or poultry enterprises on hog farms. The old saying, "Don't put all your eggs in one basket," is the motto of the Corn Belt farmer, who is far from market and lacks monopoly elements in his business.

In a more general way the figures of table 4 indicate the difference in price declines during the depression for hogs, cattle butterfat, poultry and eggs.

TABLE 3.—*Sources of cash income on a 200-acre hog farm, Benton County, Iowa, 1927–1937*

Year	Hogs	Cattle	Dairy	Poultry	Miscellaneous[1]
	Percent	*Percent*	*Percent*	*Percent*	*Percent*
1927	62	17	9	10	2
1928	60	15	11	12	2
1929	70	8	10	12	0
1930	75	3	9	12	1
1931	73	4	8	14	1
1932	51	20	13	15	1
1933	47	12	22	18	1
1934	39	21	11	12	17
1935	50	22	10	10	8
1936	74	12	7	7	0
1937	65	18	5	7	5

[1] Includes Government payments 1934-37.

in this area. A few of these commercial flocks may be found near any large city where special retail or roadside markets may be developed. Perhaps the most outstanding development in this type of production in the Midwest is in turkey production for meat and more recently for hatching eggs. But even here the enterprise tends to be one of several other farm business enterprises. Some farmers have tended to replace or supplement their hog enterprise with turkey production. In some cases this is due to inefficient methods in hog production; in others it is due to a desire to reduce the risks of an expected general overproduction in hogs.

But in general these commercial poultry enterprises require relatively large amounts of grains, purchased feeds, labor, and equipment. Naturally they require large capital outlays and entirely new techniques of production and marketing. It took several years of training to develop turkey production with farmers in the noted Wellman, Iowa, area. It required very close supervision of local packing plants to secure the adoption of proper but new feeding and housing practices.

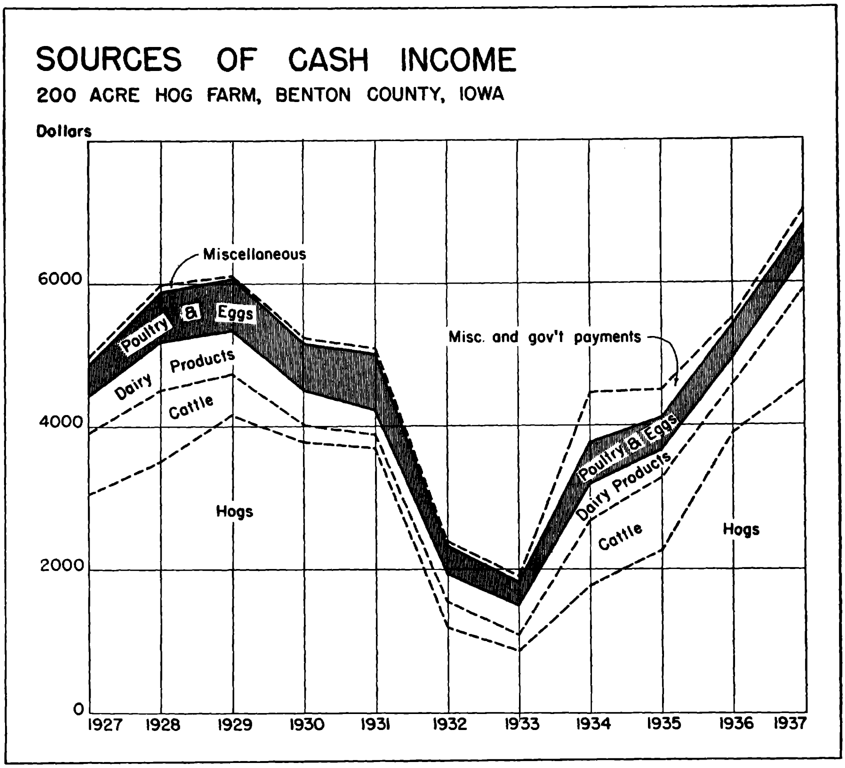


FIGURE 2.—The poultry enterprise on this farm showed much more stable cash returns, during the worst years than the other livestock enterprises.

For the three years 1932–3–4 (at the bottom of the depression)—hogs were selling at 30 percent of their 1925–29 levels, while poultry, eggs and butter were approximately 45–50 percent of pre-depression levels.

SPECIALIZED COMMERCIAL POULTRY FARM DEVELOPMENT SLOW

In contrast to the almost universal farm flock on Corn Belt farms, the specialized commercial poultry industry is still relatively unimportant

Iowa and the Midwest have developed as a hog area during the past 70 years because of the comparative advantage of hogs to utilize large quantities of farm raised grains with a relatively small amount of labor and capital required in relation to the size of farm. Table 5 which is based on unpublished Iowa Experiment Station data gives some indication as to the relative requirements for the enterprises indicated.

TABLE 4.—*Index of Iowa farm prices, January, 1925-38*
[1910-14 = 100]

Year	Hogs	Poultry	Eggs	Butter
1925-29	130	195	207	180
1930	120	173	201	153
1931	97	151	106	144
1932	47	124	83	106
1933	33	75	108	83
1934	39	78	89	75
1935	99	120	138	126
1936	125	164	115	134
1937	131	125	121	138
1938	103	172	111	134

more or less costly changes that have taken place in poultry buildings and equipment during the past twenty years. Particular reference is made to the costly but unsatisfactory semi-monitor hen house during the 1920's and the recent development of the insulated straw loft houses. With 50 percent tenancy in Iowa, these large initial investments are uneconomic because of little or no alternative use for other enterprises. There is a real need for developing poultry buildings that can be utilized by hogs or other Corn Belt enterprises on farms with frequently changing tenants.

Other deterrents to commercial poultry production involve the lack of special markets, the general lack of premium payments for quality products and the lack of specialized skill in handling poultry by the Corn Belt farm operators. All of these are in the process of changing. Undoubtedly the techniques adopted in turkey production are pointing the way for other types of poultry production, too. This has been evident recently in areas of Iowa in respect to capon production.

TABLE 5.—*Resources required to produce $100 receipts by five major livestock enterprises in Iowa*
[At 1920-29 average prices]

Resource	Hogs	Poultry	Dairy	Feeding cattle	Beef raising
Livestock required	0.76 litter	30 hens	0.78 cow	2 steers	3.1 cows
Feed units required:					
Grain	82	55	22	107	18
Commercial supplements	6	12	5	9	....
Roughage and pasture	6	2	82	33	171
Total	94	69	109	149	189
Man hours of labor	24	84	104	13	19
Capital investment[1]	$48	$85	$128	$115	$195
Management skill	Medium	Medium	Medium	High	Low

Prepared by R. K. Buck, Research Assistant Farm Management, Iowa State College.
[1] Includes livestock, buildings, and equipment.

According to these figures hogs have a decided advantage over poultry in grain consumption and labor and capital economy. The hog enterprise utilizes 50 percent *more* grain and requires only 30 percent as much labor and 57 percent as much capital investment as does the poultry enterprise. While these figures are very rough they seem to point out some economic reasons why Corn Belt farmers have not utilized more of their resources in commercialized poultry production. Admittedly, the figures are open to some criticism in regard to the price period used, but the general relationship would still be true.

Likewise the table shows the comparative advantage of such an enterprise as dairying in which large quantities of the labor resources and large quantities of roughage may be utilized. Particularly is this true in an area where legume roughage production is such an integral part of the cropping system and the soil fertility maintenance program.

A further deterrent to commercial poultry production in the Midwest States is the rapid and more or less costly changes that have taken place in poultry buildings and equipment during the past twenty years.

It should be noted that Midwest farmers have many alternative enterprises from which to choose. Naturally many different products are produced. This leads to a lack of interest both in organized market activities and to a certain extent in producing quality products. In contrast they are competing in the poultry business with farmers in areas where there are few alternative enterprises, where special markets are near at hand and where, through organized effort, certain monopoly elements of special grades, patronizing home industry, advertising, and locational advantages are created. Until new production techniques and special skills are developed and until relative prices and income of poultry products to other Corn Belt enterprises give a greater advantage in the use of the available resources there would seem to be little chance for a sudden and large expansion in Midwest poultry production on a commercial scale. Conversely there appears no reason to suppose that there will be any large reductions in production, since the poultry enterprise is established as a part of the farm business even though in most cases of minor significance to the farm operator. It is the aggregate Midwest farm poultry production that is important and not necessarily the individual farm unit production.

This viewpoint was quite definitely expressed by the 100 County Agricultural Planning committees of Iowa in their estimates of future trends in livestock production for each county. It was their opinion that increased roughage production would enlarge the cattle enterprise and more fully utilize the additional labor resources made available through reduced cultivated crop acreage. Little change in the numbers of chickens was expected by these committees. Admittedly their opinions were based on the premise of a relatively stabilized price and income situation during the next two decades.

Poultry and egg production in the heavily populated areas will probably continue to increase on a specialized commercial basis. However, these areas may meet increased competition from the Midwest areas as new production techniques and skills are adopted and as hog prices decline due to increased production and reduced foreign outlets. The Cornbelt area will continue with its present four types of farm flock production but with greater emphasis on the "Business Enterprise" and "Table Used" type of flocks. Specialized commercial poultry and egg farms in the Cornbelt will continue to be located near heavy consumption centers until greater consumption in the midwestern markets and the present advantages of eastern producers gained through legislation and other means are removed and locational advantages reduced. Improved marketing and production methods will help to solve these problems. Consequently, certain areas of the Midwest which are not able to compete in the more general type of Cornbelt agriculture may find it to their advantage to specialize on a heavy labor enterprise such as poultry and assist in solving the marketing problem involved.

A trend toward specialized meat *or* egg production by large scale producers and toward dual-purpose meat *and* egg breeds for farm flock producers seems evident in the Cornbelt. This trend is receiving an added impetus with the adoption of new production techniques and large market price differentials between light and heavy breeds in an area where cheap surplus feed grains are present. Except for certain areas, it seems that, in general, poultry production in the Cornbelt will continue its complementary and supplementary relationship to the more important hog and cattle enterprises with greater natural comparative advantages.

SUMMARY

The poultry enterprise on Cornbelt farms may be characterized as a supplementary or sideline enterprise. Poultry and eggs are produced on 83 to 93 percent of Midwest farms.

"Farm flock" describes several types of poultry and egg production on Cornbelt farms. These farm flocks are of varying size and efficiency and are characterized as: (I) Table use flocks; (II) Pin money flocks; (III) Grocery bill flocks; and (IV) Business enterprise flocks.

Because of different needs for including the poultry flock in the farm business, Cornbelt farmers (and their wives), may at some time in their farming experience produce poultry under each of these types of farm flock. Likewise, because of differences in experience, ability, tenure security, wealth accumulation, amount of capital and credit, buildings and equipment, farm acreage, market outlets, quantity and type of labor available, and relative efficiency of competing enterprises any locality may logically have different farm families keeping each of these types at the same time.

Additional important economic reasons why so large a percentage of Midwest farmers produce poultry under one of these four "farm flock" conditions are:

- High returns for feed fed, as compared to other Cornbelt enterprises.
- Desire to utilize all available family labor.
- Attempt to utilize completely available equipment and buildings.
- Small amount of capital required to start or enlarge the smaller flocks.
- Relative stability of poultry and egg prices during depression periods.

In contrast, the commercial poultry enterprise which uses relatively large amounts of grains, purchased feeds, labor, and equipment, has not developed rapidly in the Cornbelt. The chief reasons are:

- Comparative advantage of hogs in utilizing farm raised feed grains, while requiring less labor and capital to produce $100 gross income.
- Comparative advantage of dairy cows in complementing legume roughage production, thus leading to a competitive relationship with the poultry enterprise for labor, equipment and additional grain above the needs of the hog enterprise.
- Rapid and costly changes in buildings and equipment for poultry expansion which have little, if any, alternative use in other Cornbelt enterprises.
- Lack of special markets.
- Lack of quality premiums.
- Lack of developed special ability by operators.
- Competition of an area of unorganized producers having many alternative opportunities with an area of organized producers having few alternative enterprises. These organized producers also have certain acquired advantages of location, specialized grades, and advertising.

Specialized commercial poultry flocks will continue to increase in the Eastern States, but the farm flock production of the Cornbelt will continue its complementary and supplementary relationship to the more important hog and cattle enterprises. The relative importance of poultry production in the Midwest will be determined by the relative prices and improved efficiency of this and other alternative enterprises of the area.

THE CENTRALIZATION OF EGG EXPORT IN ESTONIA

By Rudolf Allmann, *Chairman, Central Association of Poultry Farming and Sales Cooperative Societies, Tallinn, Estonia*

Estonia, one of the smallest countries in the north of Europe, situated on the east coast of the Baltic Sea, 20 years ago established an independent national State. Since then Estonia has established an individual course in the trade of agricultural products. During the last 4 years the export of butter, eggs, bacon, and live pigs has been centralized by the Government. The sole right to export was given to cooperative central associations of farmers' societies.

The Central Association of Poultry Farming and Sales Cooperative Societies, "Eesti Munaeksport" (Estonian Egg Export) was founded under a special law in 1937. Formerly there were four exporters of eggs, of which three dealt in eggs as a byproduct. With the establishment of Eesti Munaeksport all previous exporters lost their right to export, and had to limit their activities to the inland market, which they did for a short time only. Since 1938 also the inland trade in eggs has mainly gone over to Eesti Munaeksport.

Eesti Munaeksport was founded as the Central Association of Egg-Societies, the members of which are local farmers and poultry breeders. Most of the egg societies were established at the beginning of 1937. Thus the whole reorganization was carried out in one year.

1921 marks the beginning of the Estonian egg export. The number of eggs exported during the first year amounted to 1,500,000 [nearly 4,200 cases]. The export has since continually increased, amounting to 48,000,000 [133,333 cases] in 1935, the highest to date. Later a slight decline took place. Nevertheless, the export is expected soon to increase again, as the interest in poultry-keeping has recently increased.

The reorganization of the egg export has greatly stimulated the poultry-keepers. The new enterprise is not solely concerned with the regulation of the export; one of its greatest aims is to develop and widen poultry breeding. For this purpose Eesti Munaeksport distributes cheaply, and under easy payment conditions, all possible kinds of poultry feeds, poultry equipment, incubators, brooders, and the like. Estonian Poultry-Keepers Association, assisted materially by Eesti Munaeksport, introduces and distributes pure and reliable breeding stock. The distribution of the greatest part of the breeding stock takes place directly on account of Eesti Munaeksport.

COLLECTION OF EGGS

In the country, eggs are chiefly collected by the egg societies. The Estonian area, which is 47,558.7 square kilometers, is divided into 62 collecting districts, in each of which there is an egg society, which has a packing station, and egg collecting stations all over its district. Thus the average egg society covers about 700 square kilometers; some are larger, and many are smaller. It is expected, however, that in the future the district areas of egg societies will be more or less adjusted to these dimensions. Accordingly there will be about 2,100 households for an egg society. As there is an average of 10 hens for a household in Estonia, in an egg society district there are some 21,000 hens. At present the larger egg societies collect about 2,000,000 to 3,000,000 eggs annually.

A great number of eggs from more distant parts of the collecting stations are brought to the packing stations by motor trucks, which pass villages at an appointed time once or twice a week. From the local packing stations the eggs are sent to the Central Packing Station of Eesti Munaeksport, at Tallinn.

GRADING PROVISIONS

All sales of eggs are made on basis of quality and weight. These innovations were introduced by Eesti Munaeksport. Formerly eggs were sold in pairs without any difference being made in quality. Now all eggs are carefully candled at collection and divided into first and second quality eggs. For candling purposes all motor trucks are specially fitted out. First quality eggs always bring the higher price. This stimulates the farmers to produce only first rate goods.

The air space of the first grade eggs is not allowed to exceed 5 mm in depth. The shell must be clean and unbroken, the egg white transparent and firm, the yolk transparent or faintly visible, remaining in the central position when turned.

Only first grade eggs are exported. All eggs collected and candled in the country are graded at the Central Packing Station of Eesti Munaeksport at Tallinn, where their quality is once more tested. Eggs are graded by most up-to-date machines, which are also equipped for candling. All eggs which have been carelessly candled at collection or which have changed their quality during transportation, are denied export.

After being graded, candled, and marked with an oval stamp "Estonia," all weight grades are packed separately in uniform cases of 360 eggs each. The weight grades are as follows: 54 pounds, 51 pounds, 46.5 pounds, 42 pounds, and 39 pounds per case. Estonia was one of the first countries in Europe, following American practice, to adopt cases of 360 eggs. In consequence even now the case of 360 eggs is called "Estonian case" in some of the European countries. The eggs are packed in white cardboard fillers and corrugated cardboard flats.

CONTROL PRIOR TO EXPORT

Before export the quality of the goods is tested by the Government Egg Export Controller. He has to open up to 10 percent of all cases and candle the eggs. Thus it is guaranteed that only strictly high-quality eggs may pass to foreign countries.

Accordingly all Estonian eggs pass a threefold test, before they are ready for export. The first testing takes place at the local packing station, the second at the packing station of the exporter, and the third by the Government Controller. There is no such strict control of the quality in any other European country. That is also the main reason why the Estonian eggs have been in such good demand on the foreign markets during the last few years in which the marketing has been systematically reorganized. Consequently the prices have considerably improved. The demand for Estonian eggs is very keen in England, in Germany, and in Switzerland.

Of the total annual export about 50 percent is sent to Germany, 45 percent to England and up to 5 percent to the other markets, chiefly to Switzerland and to Czechoslovakia. Eggs make about 3 percent of the total value of Estonian exports.

Considering the results of the centralization of eggs, one notes first a great improvement in the quality. This was mainly possible by directing the trade from one center. One can easily imagine that the competition which existed at the collection of eggs in the country at a time when there were up to 7 exporters (1925), had an undesired influence upon the quality. All traders were interested in getting a fair share of eggs, and as most of the producers were reluctant to sell their eggs on a basis of quality, most collecting stations never candled eggs for quality, and no differences were made in prices for first and second class eggs. The only way out of this was the centralization of the egg trade, which alone could secure a uniform standard quality of the product and eliminate competition among the exporters. As the fulfillment of the centralization was put directly on the producers themselves through their cooperative associations, so it is beyond doubt that the interests of the producers get the fullest attention, and considerable efforts are made to secure for them the highest prices.

Without wanting to touch the fundamental ideas of free trade and the intervention of the State, one has to acknowledge after practical experience that in Estonia the centralized export regulations have had a beneficial effect on the trade from the standpoint of both the producer and the national economy.

SUMMARY

In Estonia during the last 4 years the export of butter, eggs, bacon, and live pigs has been centralized by the Government, and the sole right to export has been given to the respective cooperative Central Associations.

"Eesti Munaeksport" (Estonian Egg Export), the Central Association of Poultry Farming and Sales Cooperative Societies, was founded in 1937 and has since carried out the regulation of exports, being at the same time concerned with the development and widening of poultry breeding.

In the country, eggs are collected by 62 egg-societies, each of which has a packing station and egg collecting stations all over its district. All sales of eggs are made on a basis of quality and of weight. Eggs are carefully candled at collection and divided into first and second quality eggs, of which only the first quality is exported. From the local packing stations all eggs are sent to the Central Packing Station of Eesti Munaeksport, where eggs are graded by most up-to-date machines, which are also equipped for candling. After being marked with an oval stamp "Estonia," all weight grades are packed separately in uniform cases of 360 eggs each.

Before exportation the quality of the eggs is tested by the Government Controller. Thus all eggs have to undergo a threefold test before they are fit to pass to foreign countries. As only strictly high quality eggs arrive at foreign markets, the demand for Estonian eggs has become very keen since the reorganization, which eliminated the competition existing among the numerous former exporters.

THE EGG AND POULTRY SITUATION IN CANADA

By W. A. Brown, *Chief of Poultry Services, Dominion Department of Agriculture, Ottawa, Ontario, Canada*

During the past 20 years the poultry industry in Canada has proven to be one of the most consistently remunerative of farm activities. There have been no phenomenal developments, no periods of great profit to producers and no extended periods when eggs and poultry have been produced at a loss. There have been times when there was more money in the poultry industry than at others, but as a whole the poultry industry has been consistently remunerative to the producer. Furthermore, notwithstanding considerable increase in production in that time it has been possible for the home market very largely to absorb that increase. Every endeavor has been made to keep an open export market for any surplus that might occur, and this has prevented any serious congestion on the home market.

This very satisfactory situation did not just happen. It is the result of long and careful planning and of a substantial and far-reaching national program or policy. In brief this program has had four basic considerations:

1. Sale by grade—the sale of eggs and poultry throughout all channels of trade, from producer to consumer in accordance with national standards of quality, and the establishment thereby, through consumer demand, of useful and effective differentials in price between the grades.
2. The graded return—the carrying back to the producer of the premium for the higher grades that the consumer has shown his willingness to pay, as the best understood and appreciated incentive to improved methods in production.
3. The dissemination of markets intelligence—the establishment of intelligence services for prices, volume, and market trends for eggs and poultry and the dissemination of information through the mail by the press and the radio, weekly or more often as required, so that, at the time of sale, both the seller and the buyer of the product may be fully informed and thus enabled to negotiate with assurance.
4. The organization—in areas where conditions warrant, of efficient producer cooperative marketing groups, thereby setting up sufficient active competition in buying to insure the producer's obtaining for his product all the markets will pay, less the necessary charges and costs of handling.

SALE BY GRADE

National standards for eggs in Canada date back to 1915 when in January they were adopted at the Annual Meeting of the Canadian Produce Association. Three commercial grades—Extras—Firsts—Seconds—were recognized, all based on quality considerations. Previously the Produce Trade of each large city had tentative standards of their own. At first, these Canadian Produce Association standards were purely voluntary, but were given a certain official status as a basis of trading between different centers, the local Boards of Trade in cooperation with inspectors of the Dominion Department of Agriculture issuing certificates as to quality as a means to facilitate trading. These systems continued for three years, following which, in April 1918, national standards for eggs were made compulsory for export and interprovincial trading, no cars of eggs being allowed to be shipped for export or between Provinces unless they had been candled and graded, the containers marked in a prescribed manner, the eggs inspected by a Government inspector, and certificates issued. The common carriers were not allowed to move them for shipment as indicated until a copy of the certificate was available and attached to the bill of lading. This arrangement has continued until the present day except that with the advent of truck transport the quantities covered have been reduced.

The result of this initial effort was a tremendous improvement in country technique in candling and grading. Not only was the standard of grading greatly improved, but it resulted in a marked uniformity in the grading throughout the whole country.

In 1921–22, the regulations covering grading were extended to include imports. Canada at that time was importing large quantities of United States eggs for re-export to Great Britain. The best eggs from these imports were exported and the undergrades left to be sold in Canada, thereby adding to the undergrades from the Canadian product, thus overloading the home market with low-quality product. It was required that the containers of all eggs imported into Canada be marked in a prescribed manner according to Canadian standards and inspected by a Government inspector before being released by Customs; further, if they had not been marked, or if the quality contained therein was not as represented, it was required that the eggs be virtually held in bond until they had been recandled and graded and brought up to the Canadian standard as indicated by inspection. Collectors of Customs were not allowed to release the eggs from Customs until supplied with a certificate from an inspector that the eggs were as represented and complied with the Canadian standards.

This requirement has remained continuously on the Canadian statutes and has proven a tremendous safeguard against the importation of low-quality product. In fact, largely by virtue of this regulation, when Canadian buyers go into a foreign market looking for eggs, they buy nothing but the best, for if they do not, the losses on the lower grades by virtue of the existing differentials in price between the grades in Canada are much greater than the equivalent of any ordinary tariff that they might be called upon to pay.

In 1923, the regulations were amended to require that all eggs in domestic trading, both wholesale and retail, be graded and the containers marked in a prescribed manner according to the Canadian standards. This departure in the grading regulations was preceded by a nation-wide demonstration of the sale by retail of eggs graded according to the Canadian standards. A number of prominent retailers were selected in each large center and arrangements were made with them whereby they were to sell only eggs graded in accordance with the Government standards for a period of three months. The expansion of business resulting was truly remarkable, many retailers extending their business 200, 300, some 400 percent, and more. The demand for eggs sold according to Government grade became widespread, with the result that the regulations were amended as indicated to include the whole field of domestic trading.

With slight changes they have continued that way for the last 16 years and are now an accepted fact in the commerce of the country.

THE GRADED RETURN

Legislation governing the graded return is a much more complicated undertaking than graded sale. This was included in Canada's Egg Regulations at the time that the regulations were amended to cover the whole of domestic trading. In graded sale the inspector with the definition of the grade before him examines the eggs as to their fitness to meet the grade stated on the container. They either are or are not up to the grade stated. In graded return to the producer it is not the eggs so much that are examined but the grading slips. Inspection is largely a matter of accountancy to make sure that the producer is receiving the existing differentials in price between the grades and further that there are no fictitious statements to cover up flat-rate buying. The producer with poor eggs would rather sell at a flat rate and is often a party to flat-rate purchase, especially when he is being paid in merchandise by the peddlar or country merchant whose business anxiety turns more on the sale of their own goods than upon any improvement or advancement in the poultry industry.

This difficulty has been met by the establishment of egg grading stations all over the country, some cooperative, mostly private. The ultimate objective in this is registered grading stations and certified graders, a system much similar to that established in creameries. It has required time to arrive at a solution of this problem especially with all the constitutional pitfalls which a regulation of this kind has to face when administered under Dominion auspices.

MARKETS INTELLIGENCE

Markets intelligence is an endeavor to place in the hands of the seller as much information about market prices and market trends as in the hands of the buyer and leave the two to negotiate the transaction. It is all part and parcel of the plan to enable producers to secure for themselves the highest possible price returns for their product. The information is collected through the branch offices located in every Province in the Dominion, and through special agents on the principal markets in other countries where Canada may trade to advantage.

The information from principal Canadian markets is prepared and distributed daily to the press of Canada through the medium of the Canadian Press, and to a limited mailing list. Radio market reports are prepared for specified regular market broadcasts. The principal endeavor is the weekly report, printed and published every Friday, which covers all markets for both eggs and poultry and is distributed to an extensive mailing list.

COOPERATIVE ORGANIZATION

While many and varied attempts have been made in many parts of Canada to organize what might be termed cooperative monopolies for the sale of the producer's product, those that have proven most successful are the smaller local cooperative units that operate in a given area, but that are sufficiently pliable to work together under a common sales organization for export and interprovincial movement. These smaller organizations thrive best in those sections that lack adequate private enterprise properly to look after the producers' interest in the way of effective grading and merchandizing. At the same time they set up an effective competition in the matter of price, with the result that the whole community benefits. The central sales agencies of these cooperatives now constitute some of the most effective and resourceful export sales mediums for poultry products in the Dominion.

These four basic considerations are the cornerstones upon which the whole superstructure of the Canadian poultry industry is being built. The graded sale establishes the premium for the better grades. The graded return carries it back to the producer as the language best understood as a means to improved methods in production. This cash incentive in the returns for the product is the best urge that the producer can have to secure better stock, improved environmental conditions, better feeding and growing practices, and better product handling methods. He has markets intelligence to advise him as to the best times to sell, the weights and quality of product the market requires, and cooperative associations to assist him in his marketing, should occasion arise.

This in brief accounts in no small degree for the steady onward progress of the poultry industry in Canada and the confident outlook for the future.

SUMMARY

Through a far reaching national program in Canada the poultry industry has become one of the most consistently remunerative of farm activities. The basic considerations in this national program are as follows:

1. Sale by uniform grades throughout all channels of trade.
2. The graded return to producers—an incentive leading to improved methods in production.
3. The dissemination of market intelligence to sellers as well as to buyers.
4. The organization of producers' cooperative marketing organizations in areas not well served with marketing facilities.

These are the cornerstones upon which the Canadian poultry industry is being built. They tend to insure the highest possible producer satisfaction in the production of quality products. The producer in Canada has become quality conscious. He has found that quality pays. He is anxious to secure the best in breeding stock, in baby chicks, in improved feeds, equipment, and environmental conditions. His anxiety in this direction has made it possible to evolve policies in breeding, in hatchery approval and in other ways. He has no fears from the importation of low-grade products from other countries, for under the regulations in effect, if imports do come in they must at least be of a quality equal to his own production in order to secure grade recognition on the Canadian market.

THE INFLUENCE OF VARIATIONS IN SECTIONAL ECONOMIC MATURITY ON AGRICULTURAL HUSBANDRY PARTICULARLY ON POULTRY

By LEAVITT C. PARSONS, *Editor, New England Poultryman, Boston, Massachusetts, U. S. A.*

This is really a paper in sociology to illustrate trends in poultry husbandry. It aims to show a definite correlation between the rate of material progress of society and concurrent changes in the type and technique of agricultural husbandry. I feel that the trend of agricultural development follows a predictable pattern provided we have available certain social and economic data by which we can measure for any community its economic maturity or industrialization. With such data it is reasonably possible to approximate without further examination the general character of the poultry husbandry of that community.

YARDSTICKS FOR MEASURING ECONOMIC MATURITY

It is possible to measure sectional economic maturity. The process of aging is both social and economic and is reflected in an entirely changed set-up of the community involved. Age alone is no measure of economic maturity. In China and in India we have cultures of great antiquity without industrialization. The true degree of economic maturity can be measured with certain selected yardsticks that reflect specific facets in a community's social set-up. Eight of these are offered here. A comparison of the derived data will indicate which of two communities is most highly industrialized. Yardsticks are: (1) Population per square mile (2) degree of urbanization, that is, the percentage of people that live in cities and towns (3) the vanishing of primary industries like mining and lumbering (4) a development of secondary and tertiary industries making industrial goods, machine tools, and gadgets (5) increase in percentage of white collar workers in trade, commerce, and the professions (6) development of large-scale servicing enterprises such as banking, insurance, engineering, transportation, and foreign trade (7) high per capita savings deposits and purchasing power (8) low interest rates.

This leads to my thesis: (a) All communities vary in their social and economic set-up, but tend to follow generally certain normal lines of development (b) with the aging of a community, agriculture also changes both in its form and in its techniques (c) without artificial interference, field crops or extensive agriculture will tend to vanish, but will be replaced by an industrialized agriculture (d) the industrialized agriculture seems always to include three major phases, dairying, poultry raising, and a horticultural group comprising fruits, truck gardening, and nursery stock (e) the United States because of its size, its high degree of homogeneity, the speed and completeness of its news and communication systems, the distinct variations in economic maturity of its major sections, provides a geographical clinic wherein the steps in the industrialization of agriculture can be observed and proven and its pattern recorded.

This thesis will be developed first by some general applications of these yardsticks and then by an effort to describe trends, indicating certain modifying factors and, finally, showing how changes in poultry husbandry serve to illustrate application of this theory.

APPLICATION

Without introducing here the supporting statistics, the application of these yardsticks to the economic and social conditions in modern Europe indicate that three countries enjoy a most pronounced economic maturity: Belgium, Holland, and England. Applying the same measures to the major sections of the United States the New England area shows the highest degree of industrialization. Next comes the Middle Atlantic States with the Gulf, South Atlantic, and Mountain States representing the least economically mature areas. In all of the older sections, whether here or in Europe, a decline of cereal growing has occurred and they are shortage areas on this type of foodstuffs. In each of these sections there has been an increase in the consumer-goods types of agriculture, made up largely of converter forms representing dairy and poultry farming. Surveying the position of the United States as a whole, it seems to be reaching its economic adolescence, for over 50 percent of the total agricultural income is now contributed by the three ascendant phases of industrialized agriculture. The increased proportion of employment in manufactures and trade make economically mature sections increasingly dependent on younger countries for supplying certain foodstuffs.

There seems to be no necessary time factor in the industrialization of a community. Growing European cities gradually influenced their hinterland and modified its agriculture over many centuries. Some young American areas have achieved an equivalent degree of industrialization in less than 100 years. Rapidly expanding eastern milksheds illustrate this. So also does the St. Paul-Minneapolis section. It thus appears that when the mechanized technique of economic maturity is immediately available the process of industrialization becomes a transplanting rather than an evolution. This must include agriculture, for the St. Paul area is already changing, presenting the diversification of industrialized forms.

TRENDS

The trends of sectional economic maturity follow the same pattern in different, often distant places. All aging communities seem to discard types of agriculture they have outgrown just as maturing youth discards short pants. Industrialization brings an increased percentage of production in consumer forms of agriculture. The local development of industrialized agricultural types closes markets that were formerly available to surplus sections. The following figures obtained during a study of the Cuban poultry industry a few years ago are pertinent. They reflect over a 5-year period declining exports from the United States probably due to a combination of local tariffs and a new poultry production around Havana: In 1927, $11,471,637; in 1928, $6,102,813; in 1929, $2,409,374; in 1930, $1,254,618; and in 1931, $104,228.

The fact that in industry the value added to the product by processing and distribution often exceeds the value added by production, holds for agricultural products also. The trend is for the farmer producing staples to get a decreasing percentage of the consumer's dollar. His proportion varies with cyclical price changes, but the producers of industrialized agricultural products enjoy a greater price stability than do the producers of bulk staples. Thus, in the depression years, the poultry of the United States contributed to the national income nearly three times as much as all the wheat. In 1932 poultry yielded $4.69 per capita, while wheat and corn sold off farms and tobacco together yielded a total of only $3.85. Cotton, another big national staple produced $3.71. It is the distress following the violence of these price reactions in the decadent phases of agriculture that have helped bring farm problems into politics. History suggests that when some phase of agriculture becomes economically less important it becomes politically more articulate. This may explain the old English Corn Laws and some of our American farm legislation.

The trend of prices for the products of an industrialized agriculture seem to follow the cost of living curves in different sections. In the study of cost of living in the United States issued by the National Industrial Conference Board for the years 1914–1927, appears a breakdown on a sectional basis indicating the combined effect of differences in index figures for city budgets in each section. The average for each region is indicated by showing its variation from the national average expressed as 100. North Atlantic, 108.81; North Central, 95.70; South Atlantic, 92.43; South Central, 91.87, and Western, 95.18.

These variations in the cost of living correspond roughly to our current findings on the relative economic maturity of the respective sections. Since all food products enter into the cost of living they would indicate that the prices received by local poultrymen and other farmers would follow the same price pattern. This seems to be borne out by the various maps and tables touching this subject issued by the United States Department of Agriculture.

The territorial specialization that we find in industrial production occurs also in agriculture. The cause is largely economic, with geology or soil content of importance in both instances. The waste factor in marketing perishable farm produce plays here the same economic function as does the freight factor or transport cost in marketing manufactured goods. Refrigeration has lessened the importance of location in producing perishable foodstuffs. Storage aims to avoid waste in price spreads by neutralizing seasonal or cyclical price changes. It may be merely shelter or some form of semi-processing, such as cheese and butter making, drying milk or canning eggs, the drift of which from farms to factory has been often noted.

MODIFYING FACTORS

Whereas the above outline indicates the normal development of inferential trends their rate may be speeded up or retarded by numerous modifying factors which directly react on decisions to be made by sectional farmers. The most important of these modifying factors may be grouped under the following heads: (a) Factors of location (b) political factors, and (c) technological factors. In the first of these we find climate, relief, soil, and distance from market. All of these bear more or less directly on the cost of production. Among the political factors are tariffs affecting imports, subsidies affecting exports, and Government regulations or interference through quota restrictions, inspection services, and foreign exchange devices (such as Germany now applies to divert her egg buyers from Holland to Denmark to build volume for the Danish-Reich Barter agreement). Under technological factors fall labor-saving machinery reducing production costs, storage and processing devices, reducing seasonal price variations, and improvements in transportation, reducing marketing costs and improving income by protecting quality. In this category come the applications of genetic science that give us high-producing dairy cattle and 300-egg hens. This represents only the application of a principle of industrial management which would regard cows and hens as productive machines on which successful operators compute unit costs.

HOW POULTRY HUSBANDRY ILLUSTRATES THIS THEORY

Although prehistoric peoples kept domesticated fowl, poultry husbandry (as distinct from egg-selling) seems to have had no recognition or commercial significance until nations began to reach economic maturity. The United States well illustrates this theory. In years we are a young country. The Federal Census of 1840 did not mention poultry. As late as 1899 the Secretary of Agriculture in his Annual Report, stated he feared that his poultry statistics "fall far short of the facts." The commercial poultry business, like the commercial milk business is less than 50 years old. It is born of invention. Artificial incubation, refrigeration and rapid transportation have made the production of table eggs an industrial enterprise relatively free from the meteorological risks that jeopardize most other kinds of agriculture. Yet those who produce eggs in America show variations in their husbandry and marketing technique corresponding closely to variations in the economic maturity of different sections of the country. These variations are quite apparent in the following five features: (1) Flock size (2) average production (3) average prices received by producer (4) the point where the risk or title passes and (5) in the type and acceptance of producer cooperatives. Maps prepared by the Department of Agriculture graphically picture the location of flock sizes by points of frequency. These show a clear correlation between flock size and sectional industrialization. Similar statistics are available for average prices received and average production per bird. The point at which the risk passes from the farmer to the consumer or middleman is also related to sectional industrialization. In economically mature areas where producers enjoy optional markets the risk remains with the producer longer. Hence, consignments. In the Corn Belt, a surplus producing area where poultry raising is an incident of farming rather than a specialized enterprise, the risk usually passes to a middleman at the point of production. In the distant Pacific Coast where rapid industrialization has spottily occurred and certain phases of agricultural production including poultry have adopted the organization and technique of large-scale industry we find egg producers setting up devices through which they can jump the intervening distance and offer producer-owned merchandise on the threshold of the big consumer markets. They use a producer-owned cooperative.

These are the more conspicuous phases of a changing poultry husbandry that would follow the pattern of industrial progress. I close with a European analogy drawn from the London egg market. This is an egg shortage area like Northeastern United States and there, as here, the local producers can supply only a small part of the sectional demand. For this London market, Holland and Denmark play the part of the Corn Belt. There we find also arrivals of good quality eggs from distant points, graded, packed, and shipped by producer cooperatives. Thus, an economically mature England finds in the cooperatives of South Africa and Australia a striking parallel to our Pacific Egg Producers who ship to New York. All of which I hope will help guide those who would prognosticate.

SUMMARY

There appears to be available sufficient historical data on agricultural economics to indicate a definite correlation between the rate of industrialization of any community and concurrent changes in the type and technique of its agricultural husbandry. Poultry raising reflects predictable patterns. It is maintained that just as human beings undergo certain changes with maturity so also do communities. We call the process industrialization. Age alone does not bring economic maturity. Certain yardsticks such as density of population, degree of urbanization, interest rates, and occupational changes must be used. When these conditions have changed it is

found that the agriculture of that section has also changed. Extensive agriculture gives way to an intensive or industrialized agriculture. The agriculture that accompanies economic maturity assumes three predictable forms (a) dairying (b) poultry raising and (c) a horticultural phase comprising fruit, truck gardening and nursery stock. These yardsticks show that Europe, Belgium, Holland, and England enjoy the greatest economic maturity. Among the sections of the United States, New England is most industrialized and certain other sections have reached their economic adolescence. This progressive pattern indicates that in agriculture as in industry the *processing function* (that is, the converter forms) are contributing more to national income than the purely *productive function*. This normal pattern of agricultural industrialization may be modified by certain external conditions, meteorological, political, or technological. The response to all of these is reflected in poultry husbandry both here and in other countries. Variations in sectional economic maturity account for variation in flock size, in average production, in average prices received, in the point where the risk passes, and in the type and acceptance of producer cooperatives.

DIE EIERMARKTREGELUNG IN DEUTSCHLAND

Von FRIEDRICH KÜTHE, *Oberregierungsrat im Reichsministerium für Ernährung und Landwirtschaft, Berlin, Deutschland*

Wesen und Bedeutung der Eiermarktregelung in Deutschland werden verständlich aus der Darstellung des Gegensatzes, wenn die Verhältnisse geschildert werden, die den Eiermarkt gekennzeichnet und auch beeinflusst haben, bevor die Marktregelung wirksam wurde.

Deutschland ist neben England das wichtigste Eier-Einfuhrland der Welt, das die zusätzlich benötigten Auslandseier aus den nordwesteuropäischen Staaten und Ländern Osteuropas und des Südostens bezieht. Diese Einfuhr konnte in jeder Beziehung nahezu ungehindert nach Deutschland einströmen, dem Importeur war der Zeitpunkt des Kaufes überlassen und ein niedriger Zollsatz stellte der Auslandszufuhr kein wesentliches Hemmnis entgegen. Bei dieser Freizügigkeit des Einfuhrgeschäftes war es nur allzu verständlich, wenn das Auslandsei zur Zeit der Schwemme, also im Frühjahr, in grossen Mengen den deutschen Markt überschwemmte und das deutsche Angebot zurückdrängte, denn auch die Verteilung innerhalb Deutschlands war an keine Vorschriften gebunden. So kam es, dass Auslandseier ihr Hauptabsatzgebiet in den Grosstädten fanden. Die beherrschende Stellung der Auslandsware war so stark, dass zu Zeiten des Eierüberflusses selbst im Weichbild der Grossstädte gelegene Erzeugungsstätten Absatzschwierigkeiten hatten, denn noch viel weniger als beim Auslandsei konnte von einer geregelten Erfassung und Verteilung des deutschen Erzeugnisses die Rede sein. Zudem war die Erzeugung, durch hohe Scheinkonjunkturpreise um unzählige Farmbetriebe, die auf Futterzukauf angewiesen waren, erweitert, alles andere als krisenfest und auf Preisrückgänge vorbereitet. Ansätze in genossenschaftlichen Zusammenschlüssen waren wohl da, sie konnten sich aber nicht durchsetzen, der Handel beherrschte das Feld, ein Handel, der seinen eigentlichen Berufszweck verloren hatte und zum Börsengeschäft wurde, das dem einen unermesslichen Gewinn, dem anderen aber empfindliche Verluste eintragen konnte. Kein Wunder, wenn bei diesem Kampf der Kräfte die Preise grossen Schwankungen unterworfen waren. Je nach der Spekulation gingen sie herauf und herunter und ganz besonders im Frühjahr, wenn das Angebot in keiner Weise dem vorhandenen Bedarf entsprach.

Die Unsicherheit einer freien Marktentwicklung zeigte sich in ihrer ganzen Gefahr erst dann, als die zurückgehende Kaufkraft das Angebot nicht mehr zu den alten Preisen aufnehmen konnte und ein ständiges überangebot den Preis mehr und mehr herabdrückte. Namentlich im Frühjahr machten sich diese Preisstürze katastrophal bemerkbar. Hier konnte nur noch eine grundsätzliche Umkehr und Abkehr vom Prinzip der Freizügigkeit die Rettung bringen, Einzelmassnahmen hatten keinerlei Aussicht auf Erfolg mehr. Die Notwendigkeit einer Hilfe war wohl erkannt und man versuchte auch, durch Erlass einer Kennzeichnungsverordnung, nach der die Stempelung von Auslandsware und Kühlhauseiern vorgeschrieben war, eine gewisse Ordnung in die Absatzverhältnisse zu bringen. Durch Zollerhöhung im März 1933 sollte das übermässige Auslandsangebot abgestoppt werden. Diese Massnahmen liessen aber soviel Lücken frei, dass eine grundsätzliche Klärung der Marktverhältnisse dadurch nicht zu erreichen war. Hier konnte nur eine sehr sorgfältige und gründliche Ordnung des Marktes helfen, so wie sie Ende 1933 nach Amtsantritt von R. Walther Darré als Reichsbauernführer und später als Ernährungsminister im Reichsnährstandsgesetz und im Gesetz über den Verkehr mit Eiern ihre rechtliche Grundlage erhielt.

Aus vorstehenden Ausführungen ergibt sich bereits, welche Aufgaben dieser Marktordnung gesetzt waren:

1. Die Einfuhr und ihre Verteilung musste einer eingehenden Kontrolle unterzogen werden;

2. es war notwendig, das für den Markt in Frage kommende deutsche Angebot zu erfassen und die verfügbaren Mengen nach Möglichkeit so zu verteilen, dass Angebot und Bedarfsdeckung keinen regionalen und zeitlichen Störungen unterworfen waren;
3. zur Durchführung dieser Aufgabe ist eine staatliche Vorratswirtschaft, die den Markt bei Überangebot entlastet und damit gleichzeitig Reserven bildet für die eierarme Zeit, unentbehrlich;
4. Einfuhrregelung, Kontrolle der Erfassung und Verteilung verfehlten ihren Zweck, wenn nicht auch die Gestaltung der Preise und Preisspannen ein ganz anderes Gesicht erhielt. Dem Preis, der früher vom freien Spiel der Kräfte Angebot und Nachfrage bestimmt wurde, kam lediglich die Aufgabe zu, die volkswirtschaftlich gerechtfertigte Verbindung zwischen Erzeuger- und Verbraucherinteressen herzustellen und als Diener der Marktordnung für die ständige harmonische Ergänzung der zu diesem Zweck getroffenen Massnahmen zu wirken.

ORGANISATION DER MARKTORDNUNG

Zur praktischen Durchführung dieser Massnahmen stehen zwei Organisationen zur Verfügung: die Reichsstelle für Eier als nachgeordnete Dienststelle des Reichsministeriums für Ernährung und Landwirtschaft und als Zusammenschluss des Reichsnährstandes die Hauptvereinigung der deutschen Eierwirtschaft mit ihren Untergliederungen. Der Reichsstelle für Eier obliegt die Kontrolle der Einfuhr in mengen-, wert- und preismässiger Beziehung. Sie wacht auch darüber, dass der Handel innerhalb Deutschlands die Auslandsware an die vorgeschriebenen Verbraucherplätze bringt. Ausserdem tritt die Reichsstelle selbst als Importeur von Auslandseiern auf. Sie hat weiter für ausreichende Kühlhausvorräte zu sorgen. Für die Regelung des deutschen Angebots und Verteilung der insgesamt verfügbaren Mengen inländischer und ausländischer Herkunft ist die Hauptvereinigung der deutschen Eierwirtschaft zuständig. Ebenso gehört die Preisfestsetzung, die der Zustimmung des Reichsministeriums für Ernährung und Landwirtschaft bedarf, zum Arbeitsbereich der Hauptvereinigung.

DIE TECHNIK DER MARKTREGELUNG

Es würde zu weit führen, hier im einzelnen die technische Durchführung wiederzugeben. Es soll hier nur das Grundsätzliche, aus dem ersichtlich ist, wie nun die Marktordnung in der Praxis wirksam wird, dargestellt werden. Die technische Durchführung der Einfuhrkontrolle und Überwachung der Einfuhrpreise bereitet verhältnismässig geringe Schwierigkeiten. In den Verträgen mit den einzelnen Lieferstaaten werden jeweils die Einfuhrkontingente festgelegt. Die insgesamt zur Verfügung stehende Menge je Herkunftsland wird dann anteilmässig auf die Importeure verteilt, mit der Auflage, diese Menge an bestimmte Verbraucherplätze zu liefern. Neben dieser Einfuhr des Handels tritt aus Zweckmässigkeitsgründen auch die Reichsstelle als Käufer auf, die ihre Einfuhr nach gemeinwirtschaftlichen Interessen, gewissermassen als Einkufäufer für die deutsche Volkswirtschaft, betreibt. Die Notwendigkeit und die Vorteile dieser Reichsstelleneinfuhr zeigen sich ganz besonders in der Vorratswirtschaft.

Im Frühjahr werden nach bestimmtem Plan die Vorräte für den Winter angelegt, die nach sorgfältigster Auswahl von geschultem Personal sachgemäss in die verschiedenen Kühlhäuser Deutschlands eingelagert und im Winter, in der eierarmen Zeit, dem Verbrauch zur Verfügung gestellt werden. Zur Einkühlung wird Inlands- und Auslandsware verwandt, die von der Reichsstelle gekauft worden ist.

Die Erfassung des deutschen Angebots erfolgt durch Händler und Genossenschaften. Voraussetzung hierfür ist der Besitz eines Übernahmescheines, auf dem die aufgekauften Eier vermerkt werden müssen. Nach besonderer Vorschrift ist alle Ware, die vom Grosshandel übernommen wird, der Kennzeichnung zuzuführen. Durch Übernahmeschein und Ausbau des Kennzeichnungszwanges ist die Marktordnung in der Lage, die aus deutschem Angebot zur Verfügung stehende Menge jederzeit zu übersehen.

Die den Bedarf des Erfassungsgebiets übersteigende Menge wird nach Weisungen der Hauptvereinigung in die Bedarfsgebiete geleitet. Für die zusätzliche Versorgung dieser Bedarfsgebiete stehen ausserdem Auslandseier zur Verfügung. Hinzu kommt als Reserve der Kühlhausvorrat, der, von der Hauptvereinigung gelenkt, über den Handel verteilt wird. Die Marktordnung erfasst also den bezirklichen Überschuss aus deutscher Erzeugung, die Auslandseinfuhr und die Kühlhausvorräte, so dass sie jederzeit in der Lage ist, die Bedarfsdeckung so zu beeinflussen, wie es das Allgemeininteresse erfordert. Ein weiteres Hilfsmittel hierfür stellt die Preisfestsetzung dar.

Die Findung des gerechten Preises, der also einmal die Interessen des Erzeugers berücksichtigt, auf der anderen Seite den Verbraucher vor Überteuerung schützen soll, gehört wohl zu den schwierigsten Aufgaben einer organischen Wirtschaftslenkung, denn hierbei ist zu beachten, dass der Preis erstens der vorhandenen Warenmenge entspricht und zweitens dem Erzeuger einen genügenden Anreiz zum Ausbau und zur Verbesserung seiner Hühnerhaltung gibt.

Die Technik der Marktregelung darf also niemals zum Dogma, zum festen System erstarren, sondern muss stets eine elastische Zusammenfügung der verschiedenen Massnahmen im Interesse des Gemeinwohles bleiben. Wenn sie im Anfang darauf abgestellt war, die katastrophal niedrigen Erzeugerpreise zu stützen und zu erhöhen, so wurde ihr bei zunehmendem Bedarf die Aufgabe zuteil, den Verbraucher vor ungerechtfertigten Preissteigerungen zu bewahren. Die Technik brauchte zu diesem Zweck nur eine andere Marschrichtung zu erhalten, ohne dass einschneidende

Umstellungen vorgenommen werden mussten. Wenn es beispielsweise früher Erzeuger-Mindestpreise gab und der Verbraucherpreis nach oben unbegrenzt war, so wurden jetzt Erzeuger-Festpreise vorgeschrieben und ein Verbraucher-Höchstpreis eingesetzt.

Die Vorratswirtschaft, die 1934 in erster Linie darauf bedacht sein musste, den Markt im Frühjahr vom Überangebot zu entlasten, hat jetzt dafür zu sorgen, unter den günstigsten Bedingungen Vorräte für den Winter heranzuschaffen. Daraus ergab sich zwangsläufig, dass nunmehr Auslandseier einen hohen Bestandteil der Kühlhausreserve bilden.

Die Einfuhrkontrolle schliesslich musste in Zeiten reichlicher Versorgung sehr vorsichtig bei der Durchschleusung des Auslandseies in den deutschen Markt verfahren. Bei zunehmendem Bedarf sah sie sich vor die Notwendigkeit gestellt, die Lieferquellen stärker auszuschöpfen und neue Einkaufsmöglichkeiten zu erschliessen, damit ausreichende Mengen von Auslandseiern für die zusätzliche Versorgung des Marktes zur Verfügung standen.

Für die Beweglichkeit von Organisation und Durchführung der Marktordnung sprechen die Erfolge. Als Beweis hierfür sei nur die Preisgestaltung angeführt, denn sie stellt ja die sichtbare Ansdrucksform und Auswirkung aller getroffenen Massnahmen dar. Es ist gelungen, die Preisschwankungen auszuschalten und an ihrer Stelle ein Preisgebäude aufzubauen, das den zeitlich bedingten Erzeugungsveränderungen wohl entsprach, im übrigen aber innerhalb dieser Zeitabschnitte stabil war. Die durch Kaufkraftminderung verursachten Preisrückgänge konnten wieder aufgeholt und dem Erzeuger ein Erlös gesichert werden, der die Wirtschaftlichkeit der Hühnerhaltung gewährleistet.

Zusammenfassend darf bemerkt werden, dass die Freizügigkeitnicht in der Lage ist, Marktstörungen, die durch Kaufkraftrückgänge und auch durch wirtschaftlichen Wiederanstieg bedingt sind, von sich aus zu beseitigen. Es muss in diesem Falle eine Ordnung nach den Gesichtspunkten des gesamtwirtschaftlichen Interesses erfolgen, die alle Faktoren zu einem einheitlichen Ganzen zusammenfügt und jederzeit dafür Gewähr bietet, dass die Einzelmassnahmen so harmonisch aufeinander abgestimmt sind, dass jeder Marktbeeinflussung von aussen wirksam entgegengetreten werden kann. Die Erfolge haben auch hier die Richtigkeit des Grundsatzes, nach dem die ganze deutsche Wirtschaft gelenkt wird, bewiesen "Gemeinnutz geht vor Eigennutz." Nur wenn das Interesse der Gesamtheit gewahrt wird und eine ständige Förderung erfährt, kann auch der einzelne den gerechten Lohn für seine Arbeit erhalten.

ZUSAMMENFASSUNG

Die Marktregelung, die Ende 1933 im Reichsnährstandsgesetz und im Gesetz über den Verkehr mit Eiern ihre rechtliche Grundlage erhielt, sah sich vor die Aufgabe gestellt, das stossweise inländische und ausländische Angebot in die Bahn einer regelmässigen Marktversorgung umzulenken und dabei dem Erzeuger auskömmliche Preise zu sichern, ohne dass die Kaufkraft des Verbrauchers gefährdet wurde.

Zur Durchführung dieser Aufgaben musste die Einfuhr in mengen-, preis- und wertmässiger Beziehung einer bis ins einzelne gehenden Kontrolle unterzogen werden. Das deutsche Angebot war zu erfassen und je nach Bedarf auf die Zuschussgebiete zu verteilen. Als Ausgleich der jahreszeitlich bedingten Erzeugungsschwankungen dient die Vorratswirtschaft.

Die praktische Durchführung der Einfuhrkontrolle bereitet verhältnismässig geringe Schwierigkeiten. Die Erfassung des deutschen Angebots ist durch Erteilung eines Berechtigungsscheines für den Aufkauf und durch Ausbau der Kennzeichnungsvorschriften möglich. Die Bildung der Reserven für den Winter erfolgt nach bestimmtem Plan aus dem deutschen und ausländischen Angebot. Die Verteilung der deutschen Erfassung, der Kühlhausvorräte und eines Teiles der ausländischen Einfuhr wird auf zentrale Weisung durchgeführt. Die im ganzen zur Verfügung stehende Menge inländischer und ausländischer Herkunft setzt die Marktordnung in die Lage, die Bedarfsdeckung nach gemeinwirtschaftlichen Grundsätzen zu beeinflussen. Ein weiteres Hilfsmittel hierfür stellt die Preisfestsetzung dar. Um ihren Aufgaben gerecht werden zu können, hat sie sich den jeweiligen Kaufkraftveränderungen anzupassen.

Für die Beweglichkeit von Organisation und technischer Durchführung der Marktordnung sprechen die Erfolge, die in der Preisgestaltung ihren sichtbaren Ausdruck finden. Die unnatürlichen Preisschwankungen konnten ausgeschaltet, dem Erzeuger auskömmliche Erlöse gesichert und die Verbraucher vor hohen Konjunkturpreisen bewahrt werden. Diese Erfolge wurden nicht auf Kosten des Auslandes erzielt, denn der ausländische Lieferant hat durch die Einfuhrkontrolle risikolose und ausreichende Absatzmöglichkeiten erhalten.

SUMMARY

The regulation of the marketing of eggs, which in 1933 received its legal standing through the law according to which the Reich Food Estate (Reichsnährstand) governs the dealing in eggs, had the task of leading the sporadic foreign and domestic supply in a more regulated course to German markets and to assure the producers of fair prices without endangering the purchasing power of consumers.

For the carrying out of these tasks, the imports of eggs had to be subjected to a detailed control with regard to quantity, price and value. The German supply was collected and distributed

according to the demands of consumption centers. The storing of reserves serves as balance for seasonal fluctuations in production. The difficulties arising in the control of imports are relatively insignificant. The control of domestic production has been made possible through the issue of trading permits and the further development of marketing regulations. The storing of winter reserves is undertaken with domestic and foreign supply according to a certain plan. The distribution of German production, of storage reserves and part of the imports takes place in connection with instructions from the central regulating authorities. The available quantity of domestic and imported eggs enables the regulating authorities to influence the supply according to general economic principles. Another measure which aids in the execution of this program is the fixing of prices. In order to fulfill its purpose, the price structure must adapt itself to changes in purchasing power.

The results obtained sufficiently illustrate the flexibility of the organization and technical execution of the market regulation; the price regulation offers the most striking example. Unnatural fluctuations in prices were eliminated, the producers could be assured of a fair return and consumers protected from unreasonably high prices. These results were not obtained at the expense of foreign countries because their exporters were given both sufficient and risk-free markets through the control of imports.

THE MARKETING OF EGGS IN ENGLAND AND WALES

By C. A. Flatt, *Senior Marketing Officer, Ministry of Agriculture and Fisheries, London, England*

To insure appreciation of the problems of marketing home-produced eggs in England and Wales, a brief review is necessary of the sources of supplies of eggs, of the production, consumption, and of the legislation passed by the British Government for the promotion of the orderly marketing of the home product. Both the Northern Ireland and Scottish Departments of Agriculture have separate schemes for the marketing of their eggs.

Supplies.—Eggs are imported into the Great Britain market from some 30 different countries. The total imported supplies in 1937 amounted to 2,938,000,000 eggs.

Home-produced supplies, which were less in 1913 than the imported supplies of eggs, now exceed imports in volume, and in 1937 reached an estimated total of 4,400,000,000 eggs. Hence 60 percent of the total supplies in the British markets in 1937 were home produced, and 40 percent were imported.

Production.—Poultry production is spread fairly uniformly over most parts of Great Britain. In Lancashire, the poultry population is especially dense. Further North, and in North Wales, the numbers of poultry kept is below the average. Many specialist producers as well as many of the farmers and small holders are located in or close around the large centers of consumption, a point of special importance in our marketing problem. A tendency in recent years to specialize in the production of eggs, even upon the general farms, is noteworthy.

The more intensive systems of poultry production widely practiced have led to deterioration in egg quality. Loss of vigor in the poultry stock has been noticed in other countries; Great Britain has been no exception. This deterioration is observed in the increase in poor shelled eggs, in the poor quality white, and in weakness of the vitelline membrane, in many of the eggs. Needless to say, the market value of such eggs is low, and unless these are segregated by skilled candling they have an adverse effect upon the whole supply.

Consumption.—It is desirable at this point to refer to consumption, and to stress that references to quality relate to quality at the time of production. Fortunately owing to better methods of marketing, the quality of eggs when they reach the consumer has improved.

The average annual per capita consumption of eggs has increased from 118 in 1925 to 156 in 1937. In 1925, 1 foreign egg was consumed to every egg produced at home, whereas the proportion in 1937 was nearly 3 to 2 in favor of the home produced eggs. These figures are not given in any disparagement of imported supplies, and tribute must be paid here to the many exporting countries who, by their good marketing organization, send such first class eggs to the British market.

GOVERNMENT ACTION

Improvement in the quality in which eggs from all sources reach the consumer, dates from the time that the Government took an active part in the organization of marketing agricultural produce. Special attention by the Ministry of Agriculture to the marketing of eggs dates from 1924 when investigations were undertaken into the whole position, and the reports and recommendations which followed were published. Subsequently considerable time was spent in the education of distributors, to prepare the ground for standardization and organization, and in 1928 provision was made by Act of Parliament for the grading and marking of home-produced eggs. Under this Act regulations were made early in 1929 prescribing grades for eggs and a voluntary marketing scheme was introduced on a plan which had been demonstrated all over the country during the previous two years. Three months after this scheme came into operation an order was made requiring the marking of imported eggs with an indication of origin under the Merchandise Marks Act.

Act of 1928.—The Agricultural Produce (Grading and Marking) Act of 1928, gave power to the Minister of Agriculture to prescribe (1) grades for eggs and (2) a grade designation mark, for eggs produced in England and Wales.

Four weight grades were provided for eggs of first quality. The grade designations, quality definitions, and the minimum weights, which have recently been modified, are now

New Laid Special, with a minimum weight of $2\frac{3}{16}$ ounces.
New Laid Standard, with a minimum weight of $1\frac{7}{8}$ ounces.
New Laid Medium, with a minimum weight of $1\frac{5}{8}$ ounces.
New Laid Pullet, with no minimum weight.
First quality. The egg must not have been preserved by any process and must be free from taint; the shell must be clean, sound, of good texture and shape. The contents must be free from blemish, the yolk central and translucent or faintly but not clearly outlined, the white must be translucent, and the air-space must not exceed $\frac{1}{4}$ inch in depth.

The use of these designations is not compulsory but is permissible by anyone, provided the eggs comply with the requirements as to quality and weight. The grading of eggs which fall below the standard with regard to quality has not been provided for up to the present, but such eggs must not be sold under the statutory designations.

Act of 1933.—A further Act in 1933 provided that contracts for the sale of home-produced eggs, in quantities exceeding 24 eggs, should be null and void unless contracted to be sold by weight or by statutory grade.

A Government mark or brand was provided for use by authorized persons in conjunction with graded supplies of home-produced eggs. This mark is known as the National Mark. Powers to authorize the use of the National Mark are vested in the Minister of Agriculture.

Provision was also made for the appropriate marking of preserved eggs and of cold or chemically (gas) stored home-produced eggs, thus enabling consumers to differentiate between these supplies and fresh eggs.

The marking of cold- or chemically-stored eggs is, owing to difficulties in the enforcement of such a requirement on imported supplies, confined to home produce. The storage of home-produced eggs has not therefore developed, owing to the public prejudice against the marks, which need not be borne by imported eggs.

Organized distribution.—With this legislation provided as a basis, the Ministry of Agriculture introduced a scheme for organizing the grading, packing, and distribution of home-produced eggs—the National Mark Egg Scheme.

Distribution in large centers of population is complicated, and the close proximity of producers and consumers encourages an undue desire among producers for direct sale, under the impression that distributing costs are reduced and better prices are secured. A scheme, which will insure organized distribution of supplies produced and consumed in small units among a population concentrated in large cities, requires first the assembly of the product in large units for grading and redistribution to shopkeepers. Direct trade, though apparently favorable to rapid distribution, is not always effective in practice, since it frequently results in instability in price, and in the holding up of supplies at different points.

To avoid undue interference with direct trade, the National Mark scheme was introduced on a voluntary basis and was primarily designed for the marketing of supplies passing through wholesale markets, especially for those produced distant from the main consuming centers.

NATIONAL MARK EGG SCHEME

The main feature of the scheme is the setting up of centers for the grading and packing of eggs to specified standards. These centers, owned by private firms or by groups of producers, apply voluntarily for authorization to use the National Mark. Authorization, which is subject to certain conditions and to supervision of the packer by Government officers, can be withdrawn at any time upon failure of the authorized person to carry out the conditions in a satisfactory manner. The packer is under no obligation to remain in the scheme and can at any time surrender his authorization.

Packers are required to pack to the statutory grades, and in standard packages, a specified proportion of their output, to be marketed under the National Mark. Although anyone may sell eggs under the statutory grades, the use of the National Mark for selling packed eggs is permitted only by special authorization.

The National Mark guarantee, and the advertisement given to the National Mark, which is used for the marketing of other agricultural produce in similar schemes, has built up a goodwill of considerable value to the packers. Eggs sold under the Mark realize the top prices in these markets, and the quotations for National Mark supplies form the basis for the prices of eggs throughout the country.

The educational value of the scheme has been widespread. The grades have been adopted, and the packing methods imitated by large numbers of the producers and distributors who operate outside the scheme.

Packing operations

Candling.—Candling, formerly only practiced to a limited extent, has now become general, and the understanding and interpretation of egg quality has undergone a vast change. Producers now realize the quality difference in eggs. Breeders are in close touch with packing stations, and commercial egg producers are exercising much greater cleanliness and care in handling their eggs. Improvement in the quality of the eggs reaching the consumer has been considerable. This improvement in home produce has reacted upon imported supplies—the Governments of other countries quickly realized the need for tightening their export regulations in order to retain their valuable market in Great Britain.

Important research into egg quality is, in the meantime, being done by the Department of Scientific and Industrial Research at the Low Temperature Research Station in Cambridge. There is still much to learn, particularly concerning production factors which govern egg quality.

Grading.—The voluntary grading system has grown in favor steadily. Many producers adopt the statutory grades in their direct sales to consumers, and both producers and consumers can practice and understand grades which are based upon minimum egg weight. Grading on this basis quickly led to the introduction of grading machinery into the packing station, and the machines now in use turn out from 5,000 to 6,000 eggs per hour to accurate weights. With these machines, approximately four operators per unit complete the operations of receiving, candling, and packing the eggs, sealing and labeling the cases.

The proportions between the grades, as shown in the last annual returns for National Mark eggs, were as follows: 30 percent Special, 51 percent Standard, 17 percent Medium, and 2 percent Pullet.

Packages.—Ten years ago wooden cases holding 30 dozen eggs were generally used. These have been displaced to a large extent by fiber-board containers which hold 15 dozen eggs. These smaller containers afford an appreciable saving in the cost of packages and in weight. The packages are convenient for handling by women, who are largely employed in the packing stations, and with the extensive facilities for road transport, which reduces the amount of handling, packages of very light weight are found to be satisfactory.

This 15-dozen package has the further advantage of being distinctive for the home trade, since it is usually found unsuitable for use by export countries.

Packing Costs

The packing operations of a number of stations working under the National scheme have been carefully costed at different times for periods of one year. The most recent returns of six stations show an average cost of 14.65 pence per 120 eggs, or approximately $1\frac{1}{2}$ pence (3 cents) per dozen, divided as follows: Collection, 3.25 pence; work room, 3.13 pence; distribution, 4.54 pence; administration and overhead, 3.73 pence.

Distribution

Supplies from the stations more remote from consuming centers are for the most part consigned to wholesalers in London and other cities. A number of these wholesalers act as agents of National Mark Egg Central, Ltd., the packers' own marketing organization. A considerable number of the packing stations, however, deliver their supplies direct to the shops. Some of the larger stations maintain a depot in a main consuming center. The short distances to be traversed, and the excellent conditions for road transportation and for telephone communication encourage direct service. The packing stations are becoming more and more the wholesale point from which the retailers buy and it is indeed necessary that they should, in view of the small margins in the sale of eggs. Many of the larger egg producers, with whom the packers are in competition, contract for direct delivery to the shops, and a number of the large organizations for the retail distribution of dairy produce and provisions have set up their own collecting and packing centers. The egg packer must, therefore, work at a low cost to provide the service demanded by the producers, and at the same time to give rapid delivery at an economic price.

Introduced at a time when production was expanding, the scheme gave a large measure of assistance to producers by introducing and establishing home-produced eggs in markets which had hitherto been held by the best classes of imported eggs, and it has now probably accomplished all it can do in its present form to improve the marketing of home-produced eggs.

Anticipated legislation under consideration will deal with both the production and the marketing of poultry produce, and will provide an essential link between producers and distributors. Successful marketing requires mutual assistance and goodwill between producers and distributors.

SUMMARY

England and Wales, Scotland, and Northern Ireland have separate schemes for marketing home produced eggs. The National Mark scheme for England and Wales is described.

Great Britain receives eggs from 30 different countries. In 1937, 2,938,000,000 eggs were imported, or 40 percent of the total supply. The estimated home production in 1937 was 4,400,000,000 eggs.

Deterioration in the initial quality of eggs is undergoing investigation. The quality of eggs passing into consumption has been greatly improved. Annual per capita consumption has risen from 118 to 156 eggs since 1913.

Under Act of Parliament passed in 1928 four weight grades with one quality standard are provided for home-produced eggs. Regulations for the marking of imported eggs, and of preserved eggs, including cold or chemically-stored home-produced eggs, came into operation in 1929.

The National Mark Egg scheme for improved marketing organization was introduced in 1929. Packing stations authorized to use the National Mark are under Government supervision.

The methods of candling, grading, and packing introduced by the scheme have been widely adopted. National Mark supplies stand at the top of the market.

Costs of packing and distribution have decreased. Recent costings of producer-owned organizations show an average marketing cost of 14.65 pence per 120 eggs, or about 3 cents a dozen.

Conditions favor distribution direct to the shop, which is widely practiced.

The National Mark scheme has now reached a stage when other measures are required. Further legislation is under consideration.

THE EGG STANDARDIZATION AND GRADING PROGRAM IN OHIO

By Ray C. Wiseman, *Ohio Department of Agriculture, Columbus, Ohio, U. S. A.*

Prior to 1930 there was little evidence of interest on the part of poultrymen in improving the egg marketing methods in Ohio. Many commercial producers were finding satisfactory individual outlets in eastern cities and because the margin of profit in the poultry business was rather large they did not feel the urge to attempt to improve their marketing system for the small additional return. Beginning in 1930 it became less profitable to ship to eastern markets except during a very short season of the year, and interest in improving egg marketing sprang up in almost every section of the State.

BEGINNINGS IN 1932

During 1932 two cooperative poultry producer organizations started marketing eggs on a quality basis in Ohio. This was the beginning of the first real system of graded egg merchandising in the State. Rather than set up their own grade requirements, these organizations requested the Ohio Department of Agriculture to adopt the standards for size and quality of eggs promulgated by the United States Department of Agriculture. The grade standards previously used in this State fluctuated to meet the immediate situation—when good eggs were scarce the grade requirements were lowered and when good eggs were plentiful the grade requirements were raised. Competition between buyers was frequently complicated by the lowering of grade standards, and the determination of grade was largely a matter of agreement between the buyer and the seller. Progress made by one organization in attempting to pack graded eggs was frequently broken down by other organizations working in the same territory.

Producers lacked interest in a graded-egg program because they did not have confidence that they would receive fair treatment. Country handlers were not interested because it was difficult for them to find city outlets that would pay them a premium for quality eggs. The city wholesalers were reluctant to pay a premium for graded eggs because the country handlers would not maintain uniform grades.

ADOPTION OF FEDERAL STANDARDS FOR GRADE

Previous attempts to market eggs on a graded basis had made little progress. The prevalent market terms of Extras, Extra Firsts, Firsts, Seconds, No. 1s, Specials, and Henneries, as applied to eggs meant a variation of qualities depending upon each packer's conception of just what constituted the particular grade and what he could pass off in the terminal market. These old terminologies of grades have outlived their usefulness now that we have the U. S. Standards for grade.

The official egg grading service has been built in Ohio in cooperation with several egg producer marketing organizations and independent egg marketing organizations desirous of improving their methods of marketing and handling eggs. At the close of 1938, 20 organizations were using this service.

To be able to use this service the management of each plant must sign an agreement to employ a Federal licensed egg grader. It is this grader's responsibility to see that the eggs packed by the plant conform to the grade indicated by the official grade stamp appearing on the pack. A Federal-State supervisor inspects the eggs packed by the stations at intervals frequent enough to make certain that all eggs packed are properly graded.

This inspection may be made at the country packing plant or at any point where the eggs may be picked up in their movement to the ultimate consumer. The official grade stamp on the end of each case and on the tape which seals the eggs in the case carries the date on which the eggs were packed, and a grader's certificate in each case indicates not only the plant at which the eggs were packed but the individual grader who actually candled the eggs.

One of the main objects in adopting the U. S.

Standards was to help build the confidence of the egg producer, the handler, and the consumer in egg grading, and in the long run to build better markets for dependable quality eggs. Until this time Ohio eggs did not have a quality reputation on any market and Ohio egg producers, retailers, consumers, and handlers of eggs did not have any confidence in the standards used by each other. Today the majority of the large poultrymen market their eggs on a quality and graded basis, and a large percentage of them market their eggs through the organizations that use the Government egg grading service. They are doing this because they receive a premium for quality, or a price based on the quality of eggs they produce, and because they have confidence in the fairness of the grading and marketing program.

The expansion of the use of official U. S. Standards for graded eggs in Ohio has affected the entire marketing picture because it has tended to change the methods of buying, selling, and handling of eggs used by all dealers regardless of whether they are using Government grades. In most cases today the marketing organizations in Ohio are handling better quality eggs than ever before. They are placing more emphasis on the farmers' caring for their eggs and they, themselves, are following better methods of handling eggs in their plants. Though often they do not actually buy eggs on a graded basis they are in many instances paying the producers of lower quality eggs a lower price. In other words, they are grading the producers into two classes, those who produce poor eggs and those who produce good eggs, and are paying the latter a premium.

INCREASED VOLUME REFLECTING TRADE APPROVAL

The development of Government egg grading has met with approval from many retailers. Most retailers wanted to sell their customers good quality eggs but they were at the mercy of the wholesaler and had to accept his grades. So long as the consumer did not object too much, the retailer had no way of knowing whether he was getting good, medium, or poor eggs. Today the retailer who wishes to buy good quality eggs can buy Government graded eggs; and if for any reason he suspects that they do not meet the grade, he can call for a reinspection and learn definitely whether he is being treated fairly.

During the last six months of 1932, 14,000 cases of eggs were packed according to Government grades. In the year 1933, the volume jumped to 53,886 cases. During 1934 the volume increased 123.5 percent to a total of 120,455 cases. 1935 showed an increase of 18.8 percent over 1934 and 1936 an increase of 20.7 percent over 1935. During 1937 the volume jumped 50 percent above 1936 with a total of 259,285 cases packed. 1938 showed an increase of 25.3 percent over 1937 with a total of 324,952 cases packed. During the entire period of seven years the volume of eggs packed according to government grades in Ohio jumped from 14,000 cases to 324,952 cases (figure 1).

This expansion in the use of Government grades for eggs in Ohio would not have taken place had it not been beneficial to the industry. Its growth undoubtedly resulted from the fact that it developed a fair basis of trading not only between producers and dealers, but between dealers and wholesalers and between wholesalers and retailers. Ultimately the growth depended upon the ability of the program to bring better quality eggs to the consumer.

At present, the bulk of Ohio Government graded eggs is sold in case lots although a few organizations pack most of their U. S. Specials, U. S. Extras, and U. S. Standards in 1-dozen cartons for the retail trade. When the eggs are sold in cartons each carton is sealed with a certificate of quality which states the grade and the date on which the grading was done. This certificate is issued by the authority of the United States Department of Agriculture and the Ohio Department of Agriculture. The volume of eggs sold in cartons sealed by the official certificate has increased each year since 1935. During 1935 750,000 dozens packed in this manner were sold. The volume increased 60 percent in 1936, 8.5 percent in 1937. In 1938 1,315,920 dozens were sold, an increase of 75.4 percent over 1935 (figure 2).

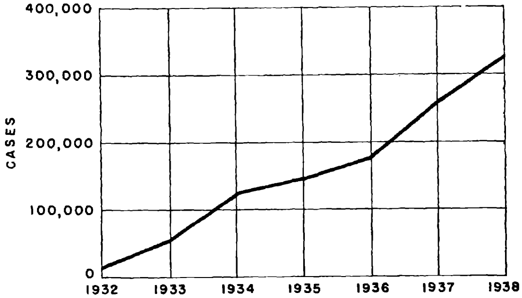


FIGURE 1.—Volume of eggs packed according to Government grades in Ohio, 1932-38.

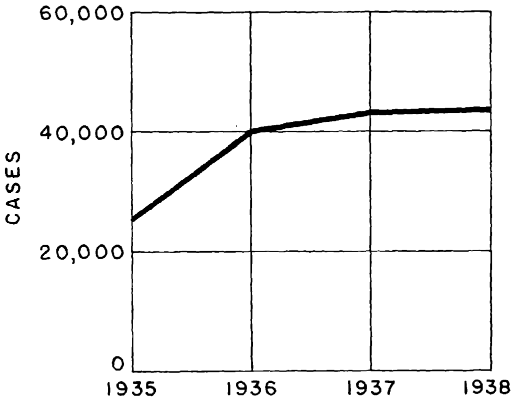


FIGURE 2.—Volume of eggs sold in cartons sealed by official certificate, in Ohio, 1935-38.

PROGRESS OF A TYPICAL ASSOCIATION

Seven years ago there had been just enough work on quality egg production and marketing to prove to the egg producers that they could produce fine quality eggs and that there was something seriously wrong with their markets and marketing methods. With the knowledge that fine quality eggs could be produced and that there was a demand for such fine quality in the eastern markets, and having been convinced that a greater demand could be built in Ohio cities and in nearby markets for a higher quality egg than had been offered in the past, two cooperative egg producer organizations started the present quality program back in 1932. Accomplishments of one of these pioneer associations, the Wooster Cooperative Poultry Association at Wooster, Ohio, are described as follows.

The organization started with a membership of 131 producers. During the first full year of operation they sold 21,279 cases of eggs. Last year, which was its sixth year of operation, this organization served a membership of 440 producers and handled 47,525 cases of eggs. During the first year of operation of this auction, top quality eggs sold at an average of 4.7 cents less per dozen than the New York quotation on Midwestern Specials. Each year this margin below the New York quotation has been decreased, until in 1938 the same grade of eggs at the Wooster Egg Auction averaged 0.9 cent more than the same New York quotation.

The history of the Wooster Cooperative Poultry Association therefore shows not only an increase in membership and in volume, but also a gain of approximately 5 cents in the average price of the top quality eggs in relation to the New York quotation.

Another interesting feature in this development is that the percentage of the eggs sold by this auction to Ohio outlets has likewise shown a steady increase. During the first year of the Wooster auction about one-third of the volume of 21,279 cases was sold through Ohio outlets. Each year the volume of eggs going to Ohio outlets increased. During 1938, 30,043 cases or 67.3 percent of the total volume went into Ohio outlets. This increase in the use of top quality eggs in Ohio from this organization is typical. Yet seven years ago people engaged in egg marketing in Ohio were convinced that Ohio consumers would never pay a premium for quality eggs.

RESULTANT PRICE ENHANCEMENT

A reputation has been built in the leading egg markets for Ohio Government graded eggs. The markets have confidence in the uniformity of the quality and grading. During the first two or three years after this program was started, the bulk of the top grades of eggs were marketed in the eastern markets, such as New York and Philadelphia, because local markets were not ready to pay a premium for fancy quality eggs. At the beginning, in 1932, the New York quotation on Midwestern Specials, (the quotation on which Ohio top quality eggs were based), averaged practically 9 cents higher than the quotation for top quality eggs on the Cleveland markets. The demand for quality eggs has increased in nearby markets and is reflected in a narrower price difference each year except 1938. In 1932 the difference between quotations averaged 8.96 cents, decreasing to 6.76 cents in 1933, 6.35 cents in 1934, 4.45 cents in 1935, 3.86 cents in 1936, 3.49 cents in 1937 respectively. In 1938 the difference was 4.60 cents (figure 3).

Marketing conditions in Ohio had changed by 1935 so that there was no price advantage in shipping the top grade eggs to eastern markets. By that time the largest percentage of Ohio Govern-

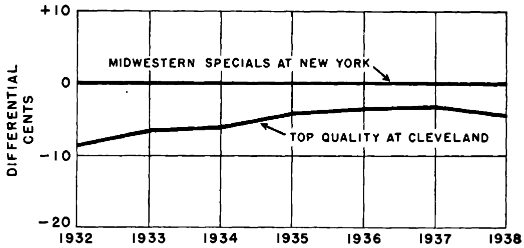


FIGURE 3.—Price differentials: Top quality eggs at Cleveland from New York quotation on Midwestern Specials, 1932–38.

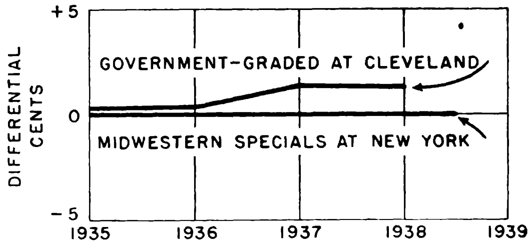


FIGURE 4.—Price differential: Average top quotation on Government-graded eggs in Cleveland from New York quotation on Midwestern Specials, 1935-38.

ment graded eggs was sold in the Cleveland and nearby markets at a price higher than the prevailing quotations. This situation developed an entirely different market in Cleveland and created a demand on the part of all organizations handling Government graded eggs for daily price quotations on these eggs. Such quotations are now provided through the cooperation of the Farm Bureau Cooperative Egg Marketing Association and the U. S. Department of Agriculture in each daily newspaper.

Comparing the average top quotation on Government graded eggs in Cleveland, with that of the average top quotation of Midwestern Specials in New York, in 1935 the Government quotation in Cleveland averaged 0.19 cents over that of the Midwestern Special quotation in New York, 0.22 cents higher in 1936, 1.36 cents in 1937, and 1.20 cents in 1938 (figure 4).

SUMMARY

Improving the methods of marketing a food product is a complex undertaking, involving the interests of producers, middlemen, and consumers. If these groups can be influenced to interact and co-act effectively a sounder marketing program, with benefit to all, is likely to emerge. These fundamental considerations are discussed in the analysis of the egg standardization and grading program as it has developed in Ohio since 1932.

Reviewing the progress and accomplishments of the development of the use of Government egg grades in Ohio, it may be safely stated that this program has resulted:

1. In the development of confidence in the soundness and fairness of the marketing of eggs on a graded basis by producers, distributors, retailers and consumers.
2. In the development of Ohio markets into outlets for good quality eggs.
3. In multiplying the number of producers who sell their eggs on a quality basis, which has stimulated better production methods and better handling methods.
4. In establishment of price quotations on Ohio markets for high quality eggs, which has benefited all producers.

METHODS AND COSTS OF MARKETING IOWA POULTRY AND EGGS

By A. D. ODERKIRK, *Extension Assistant Professor of Agricultural Economics, Iowa State College, Ames, Iowa, U. S. A.*

DESCRIPTION OF THE IOWA PRODUCING AREA

Iowa is a typical State of the midwestern area in its production and marketing of poultry and eggs. The poultry enterprise consists of relatively small farm flocks found on over 93 percent of the farms in the State. Iowa's large income from poultry and its importance nationally as the largest poultry and egg producing State is due to the large number of farms having a poultry enterprise, rather than to specialization within any section of the State.

The predominant type of poultry producer is the general farmer with a more or less diversified cropping system, supplemented with one or more livestock enterprises. Though chickens are most common, turkeys, ducks, and geese are also important.

Specialized poultry producers have been uncommon in this area. There is an increasing number of such producers, however, on small acreages, usually near the cities. Such producers devote a major part of their time to poultry and egg production.

The turkey enterprise has shown the most significant trend toward commercialization. Production of turkeys has increased from 112,000 raised in 1929 to an estimated 1,650,000 raised in 1938. The turkey production is largely sponsored by hatchery, feed, or marketing interests. Turkey production is widespread but is most intensive in three sections—southeast, northwest and north central Iowa.

There is also a trend toward production that may be classified midway between the specialized producer and the general farmer. Some farmers are finding that they can easily adopt poultry raising as a major farm activity because of the relatively low costs of feedstuffs, access to market, and the income from poultry which is made possible through low costs and direct marketing opportunities. As a result, flocks of 1,000 or more birds are becoming more common on farms and the income from poultry in such cases may be larger than that from any other farm activity. Alternative farm enterprises present greater potential income for labor and investment than poultry, which reduces the possibility of its being of commercial size on most farms.

The town or city dweller with a small backyard flock is of little trade importance. Such production is largely intended for home or local needs.

THE SIZE OF THE IOWA POULTRY ENTERPRISE

The average annual cash income from poultry and from eggs has been $19,285,000 and $24,526,000 respectively, for the 5-year period (1933–37). This constituted 9.9 percent of the total Iowa cash farm income for that period. Of this income, 44 percent comes from poultry meat and 56 percent from eggs.

The annual cash income from poultry and eggs is derived from the widespread production—on over 93 percent of the 209,737 farms in the State in 1937. There is no particular concentration of poultry production, although the northern section of the State has a larger poultry population than the southern part. Production is heaviest in the dairy and the cash grain surplus producing sections of the State.

The average number of chickens per farm on January 1, 1935 was 132, while 213.9 chickens were raised per farm during the previous year. About 941 dozen eggs were produced per farm in 1934, of which about 759 dozen were sold off farms.

Iowa flocks are regarded as of the farm-flock size, but the 1930 census reported that 8.8 percent of the flocks were of 400 birds and over. In other States of large production at that time the percentages were: Washington 8.5, California 12.9, Utah 7.2, Delaware, 8.4, New Jersey 14.4, Missouri 7.2. The first three named, (Pacific and Mountain States) and New Jersey and Delaware (Atlantic Coast States) have specialized production. The Missouri production is of the general-flock type.

There has been an increase since 1930 in numbers of large flocks in Iowa though relatively less than in the specialized sections of New England.

The United States Census of 1935 indicated only New Jersey and California as having a larger number of birds per farm than Iowa on Jan. 1, 1935, while New Hampshire, New Jersey, Delaware, and California exceeded Iowa in numbers of chickens raised per farm in 1934. Rhode Island, New Jersey, Delaware, Utah, Washington, and California exceeded Iowa in egg production per farm in that year.

While Iowa is not the leading poultry State in terms of production per farm, its production in the aggregate provides sufficient income to warrant attention from producers to their marketing problem.

The gross income per farm from the poultry enterprise at the time of the 1935 census approximated $308 or 13 percent of the total gross income and 15.6 percent of the livestock gross income. The cash receipts from poultry and eggs per farm were $239 which was 11.3 percent of the total cash receipts and 13.4 percent of the livestock receipts.

The poultry enterprise thus has an important part in the farm enterprise of the State, although it is overshadowed by at least three livestock enterprises which provide greater total returns to Iowa producers. Poultry and eggs during the period 1929–37, inclusive, has ranked fourth in cash income among the major agricultural products, hogs, cattle, diary products, and poultry ranking in the order named with respect to farm income. This enterprise may show wide fluctuations in volume as climatic conditions influence feed costs or as market values are favorable or unfavorable. However, the place of poultry is established as an essential part of the farm business because of plentiful feed supplies, ready access to markets, and the small investment required.

QUALITY AND TYPE OF PRODUCTS

Since the production of poultry and its products in Iowa, as indeed throughout the Middle West, has been regarded as incidental to other livestock or grain enterprises, quality has been given less attention and may vary more than that of the products of specialized areas. Eggs thus may show greater lack of uniformity in shell condition and color, yolk color, size, and other factors. Reduction of the variation in market shipments is not an insuperable obstacle, if market agencies will adopt uniform grades both in assembling and in preparing the product for market. While uniform products cannot be attained without controlled production methods, the variability in market receipts could be much lower than it is at present. Similar variability is in evidence with poultry meat because of the large numbers of farms participating in poultry production, with a diversity of breeds and varieties, and at different ages and in differing degrees of finish when marketed. Greater uniformity exists in poultry packs than in egg packs prepared for shipment to consuming markets because of the importance of New York in reflecting the dressed poultry market preferences and in establishment of uniform quality grades and weight classifications.

Eggs produced are mainly from the heavy breeds. This has resulted in a predominance of brown or creamy shelled eggs. The production of these heavy breeds has also resulted in the marketing of heavy type fowl and of roasters of a weight of 4 pounds and over, which give this State its designation as a "roaster" area.

A significant trend toward fewer breeds and varieties has been noted during the past few years.

TABLE 1.—*Varieties of poultry in hatchery flocks on Iowa farms*

Variety	1931	1934	1937
	Percent	*Percent*	*Percent*
White Leghorn	21.4	20.3	30.9
White Plymouth Rock	16.8	23.3	26.3
New Hampshire	.....	.....	9.3
Barred Plymouth Rock	11.6	8.5	8.9
Orpington	12.8	10.1	5.8
White Wyandotte	11.6	8.0	4.4
Buff Plymouth Rock	3.5	4.5	3.8
Rhode Island Red	9.7	6.4	3.7
Jersey Giant	.....	2.1	2.1
Buff Leghorn	2.8	1.7	1.7
Minorca	2.4	2.7	.9
Other breeds and varieties	7.4	12.4	1.5
Cross breeds	.....	.....	.7
Total	100.0	100.0	100.0

1931 data from a survey of 604,871 birds in hatchery flocks under Iowa Poultry Improvement Plan. 1934 data from a survey of 605,000 birds in hatchery flocks under Iowa Poultry Improvement Plan. 1937 data on 355,520 birds in hatchery flocks operating under the National Poultry Improvement Plan.

The hatcheries of the State have recognized the desirability of concentrating breeding effort upon fewer breeds and varieties and producers have expressed a preference for varieties having greater utility value as either egg or poultry meat producers, over birds of multi-colored varieties. Most pronounced is the increase of White Leghorn fowl for egg production and of White Plymouth Rocks, which have general purpose qualities (table 1). The white-feathered varieties thus are considerably in the majority of poultry produced in the State.

No particular trend toward either increased poultry meat production or egg production is evident, since the relative feed, poultry, and egg prices and supplies largely determine the choice of breeds most suitable for either purpose.

In years of satisfactory egg values and lower poultry returns a trend toward egg breeds may be evident, which may be changed by higher poultry meat values. The usually plentiful supplies of feeds and generally satisfactory returns for poultry reduce the possibility of any sustained trend from general purpose breeds to egg breeds. The necessity of much heavier egg production by egg breeds to equalize the returns from a smaller number of eggs but higher values for poultry meat from general purpose breeds has maintained the status quo of general purpose and egg breeds in the State.

While shell eggs and undrawn dressed poultry constitute the larger share of shipments from the State, live poultry is sold seasonally through truck shipments mostly destined for midwestern terminal markets, and frozen liquid eggs are being prepared in increasing volumes. Drawing of poultry is as yet undeveloped as an important phase in processing, though an increasing number of plants are preparing drawn poultry.

The extent of development of the frozen egg industry appears to be dependent upon the price level to producers and the increased usage of frozen eggs by bakers and confectioners and for industrial purposes or further preparation of egg powders. Economies involved in handling frozen or dried eggs would appear to encourage the development of this phase of the industry, if additional markets can be exploited. The factors combining against an increase in preparation of frozen eggs in plants within the State are the present possibility of an oversupply in years of heavy egg surpluses because of limited markets, distance from market, and the local price level for shell eggs. The largest percentage of eggs for processing into frozen form are now purchased on a weight basis as current receipts, while dirty or cracked eggs are a smaller percentage of eggs used for this purpose than formerly. In addition to weight requirements in buying shell eggs, quality standards for frozen eggs are increasing the demand for better eggs for breaking.

GEOGRAPHICAL AND SEASONAL RELATIONS WITH CONSUMING MARKETS

The marketing problem of an area increases in direct relation with the distance from its market. In this respect the farm flock producer is relatively accessible to certain midwestern markets but has little ready access and direct opportunity to learn about eastern consuming markets' demands, because of the type of production and market methods which have developed in this area. It is estimated that the movement of eggs from producers in this area to eastern consumers for current consumption requires a period of 12 to 20 days through the usual channels of trade. Although poultry requires a longer period for processing and fattening, the marketing period does not involve an appreciably greater time from farm to the consumer's table than for eggs because of the more direct marketing of poultry from farms to processors or shippers.

Increased development by Iowa producers of nearby out-of-State markets or of local consuming markets offers one solution of the market problem they face at present. A significant feature of midwestern terminal markets and of local markets is the lack of organization for merchandising quality products. This reduces the opportunity for concerted action in improving consumer acceptance of quality products.

Eastern markets continue to be the principal outlet for Iowa eggs. Data collected by the Division of Dairy and Poultry Products of the United States Department of Agriculture indicate the importance of four of the larger markets as outlets for Iowa eggs and poultry (table 2).

TABLE 2.—*Receipts at four markets of eggs and poultry from Iowa, 1933-37*

Year	At New York	At Chicago	At Boston	At Philadelphia	Four markets receipts	Total Iowa shipments
Eggs						
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Cases*
1933	16.7	21.3	21.3	11.9	18.0	2,497,000
1934	16.8	25.3	23.5	11.7	19.4	2,488,000
1935	15.3	24.4	22.0	7.4	17.9	2,238,612
1936	16.3	24.3	23.6	10.2	18.3	2,509,890
1937	17.6	24.1	24.5	11.8	19.7	2,670,000
Poultry						
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Pounds*
1933	17.07	17.50	15.67	17.91	16.97	64,578,000
1934	19.78	20.09	16.67	17.65	19.12	63,960,000
1935	17.26	28.85	18.35	16.71	19.11	55,850,000
1936	18.55	24.60	19.90	16.97	19.64	69,458,000
1937	18.65	23.55	20.32	13.85	19.17	62,980,000

Data from annual reports of Receipts at 4 markets by States. U. S. Department of Agriculture, Division of Dairy and Poultry Products. Some duplication exists in inter-market shipment of eggs as reported.

TABLE 3.—*Movement of Iowa poultry and eggs to market, by months, 1928-37*

Product	Jan.	Feb.	Mar.	April	May	June
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Poultry	8.84	4.39	3.02	2.39	2.52	5.08
Eggs	2.71	3.84	10.50	18.54	19.32	14.62
	July	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Poultry	5.64	6.04	8.49	13.91	19.37	20.31
Eggs	10.07	7.62	6.00	3.71	1.55	1.52

While local consumption takes a large volume of these products, the greater share of the annual production is shipped out of the State. The distribution of Iowa egg and poultry production is shown in figure 1. Slightly over 65 percent of the eggs produced and 63 percent of the poultry produced is sold out of the State.

The four markets receive the greatest amounts of these products because of their price influence and consumer demand. There is little movement of eggs to western markets. Some poultry is shipped to western markets because of the shortages in certain types and sizes of poultry in some of these markets.

Only small amounts of poultry are dressed on farms and those principally for sale to local consumers.

Seasonality of production and marketings in Iowa is considered typical of the midwest area. This is shown by table 3 which indicates the monthly percentage of marketings (average 1928–37 inclusive).

Over 50 percent of the annual movement of poultry and eggs occurs during three months of the year, respectively. While this movement occurs at the lowest price periods of the year, no marked trend can be observed in the past ten years away from the highly seasonal movement. Changes in fall and winter egg production, earlier sale of turkeys than formerly and during the recent drought period, and increased sale of chickens at lighter weights has changed the total percentage of seasonal marketings only slightly from former periods.

The seasonality of market movement makes this area more dependent upon the storing function than other areas which have adjusted their marketings to periods of shorter supply for sale of freshly killed poultry or fresh eggs.

The problem of seasonal marketings which confronted the marketing agencies in this area has partially explained the large scale facilities built to care for peak loads of poultry and eggs. Were marketings less seasonal the assembling and processing would be more efficient than with the present situation of extreme scarcity and peak marketing periods.

MARKET AGENCIES IN IOWA

The largest group of direct handlers of eggs from Iowa farmers is the group of nearly 5,000 stores out of a total of 7,501 egg buyers licensed in 1937. Next are approximately 1,500 produce stations, followed in order by part of the 690 hatcheries in the State and 239 carlot shippers, the remainder consisting of about 80 cooperative associations, and miscellaneous buyers and hucksters. Poultry licenses issued in 1937 numbered 2,990 of which buying stations were in the majority with 1,513 licenses, followed by stores with 854 licenses, carlot shippers with 239 licenses, and cooperative associations, hatcheries, and miscellaneous buyers or hucksters. The competitive aspects are emphasized by the number of buyers per farm, there being 73 farms per poultry buyer and 27.9 farms per egg buyer.

The large number of buyers reflects a highly competitive situation both as to price variability, differing grades or no grades being used in purchasing of eggs, and to a number of weight and quality bases for poultry.

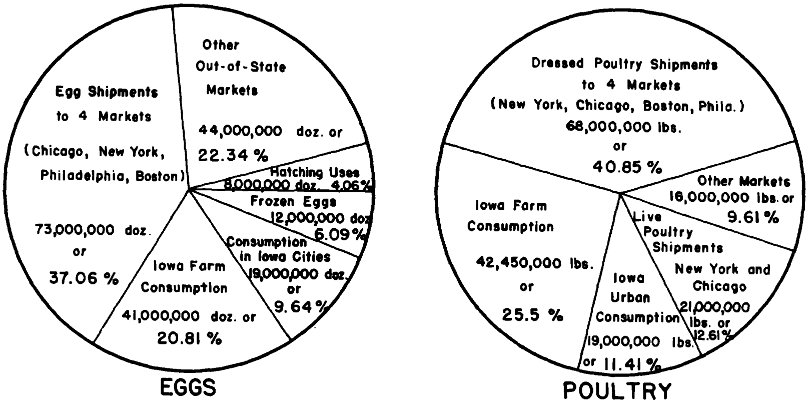


FIGURE 1.—Estimates of Iowa production and sales of poultry and eggs from farms (1931–35 inclusive). U.S.D.A. Misc. Publication 158. Consumption based on U.S.D.A. estimates of per capita consumption in U. S. (1931–35 inclusive). All poultry expressed in live poultry weights.

SERVICES REQUIRED IN MARKET ASSEMBLING AND DISTRIBUTION

The problem of economically assembling poultry and eggs from a multitude of producers in a highly diversified area is intensified because of the type of poultry enterprise in the area, the large numbers of buyers in this industry, and the heterogeneity of grades in the terminal markets which affect the country assemblers' grading and buying methods.

The methods used in assembling poultry and eggs are more variable than with most other farm products in this area. While the small unit production per farm is in part responsible for the diversity of assembling methods, the influence of terminal markets upon methods of buyers in primary markets appears to be a considerable factor in accounting for variations observed. Buechel and Kedzinski[1] report a marked correspondence in

[1] Buechel, F. A. and Kedzierski, S. L., U. S. Department of Agriculture, Mimeo. Circ. Analysis of the Price-Making Forces in the New York Market.

the movement of annual and monthly average prices of comparable grades of eggs in the four principal markets to which Iowa eggs are shipped. The degree to which monthly prices at these cities regularly move together was shown in this study by coefficients of correlation for the period 1910–32—for New York and Chicago prices +0.998 and for New York and Boston +0.999. Short-time variations were greater than this high correlation indicates. Chicago prices during that period moved along at a difference in level approximating freight charges between Chicago and the Eastern Seaboard. While price relationships may be close, the variations between these markets in grade requirements, and the desirability of using several markets with heterogeneous grades as outlets for eggs during a season, increases the variability in country buying methods. Thus the country assembler may during one season of the year ship to several markets, each having different grade specifications or preferences for eggs or poultry. The adjustment to meet these variable market requirements has resulted in flexible and nonuniform assembling methods. The Iowa shippers of eggs to distant markets can adjust buying and grading methods only as fast as terminal market practices and producer acceptance of changed practices will permit.

TABLE 4.—*Outlets of Iowa farmers for their poultry and eggs*

Outlet	Eggs	Poultry
	Percent	*Percent*
Country stores and retailers	65–85	5-10
Packers and shippers	2- 6	25-30
Commercial hatcheries	3- 5	....
Local buying stations	5-20	50-55
Direct to consumer	less than 1	1- 2
Hotels, bakeries, restaurants	less than 1	1- 3
Hucksters	1- 2	5- 7
Direct shipping to consuming centers	less than 1	less than 1

Lack of standardized practices in respect to quality grades and weight classes, which fail to provide an incentive for quality production, continuation of the barter method of selling eggs and to a lesser extent of poultry, failure to provide holding methods proper for maintaining quality in market channels, slow movement of products to market and too many handlers with resultant competitive wastes have characterized assembling methods for a large percentage of the eggs and poultry marketed.

The producer's choice of a market outlet for his poultry and eggs may be determined by other considerations than economy of services. Much of Iowa's production is sold by farmers to local agencies who in turn sell to other local assemblers in nearby areas as shown in table 4.

The producer's choice of market outlets for poultry and eggs is motivated less by consideration of future objectives than by current considerations of average price quotations and accessibility of market agencies. Thus the market buyer who appeals to the producer to change his outlet for products must offer economic inducements to producers to overcome their inertia.

Much of the egg production is sold to stores by farmers and these in turn sell to carlot shippers or truckers to the terminal markets. A majority of the poultry is sold to local buying stations who in turn sell to processors or truck shippers to the terminal markets.

Thus the carlot shipper or processor and the trucker to the terminal market are eventually the principal handlers of these products, although several agencies may intervene between these buyers and the producer. While the producer in nearly every community of the State has a choice of several outlets for poultry and eggs, his choice of outlets does not generally appear to be based on those most likely to improve the status of his marketing.

Sorting and grading of eggs

The variability of market specifications is particularly noticeable with respect to eggs. This has increased the complexity of grades used in this State for purchase of eggs from producers and has affected the way in which they are merchandised to distant markets.

Candling of eggs is required under regulations of the State Department of Agriculture and is generally practiced. Up to and including 1925 all places purchasing eggs on grade were located in the northeastern Iowa dairy section. Egg grading had developed considerable momentum until the recent depression years, but grading declined during and since that period. While grade buyers are found in all counties at present the percentage of eggs purchased on grades is relatively small. Uniform grades between local markets are found over the State only where plants of the same organization are found. Until greater uniformity occurs in terminal market grades such variation in buying methods is likely to continue in primary markets in this and other areas.

The return from ungraded eggs may provide greater income to certain producers of low quality products than would be secured if the eggs were graded. However, the market agency bases paying prices upon the net return for the product. Since quality is one of the important factors determining market returns, the price for ungraded eggs must include an allowance for grading losses. This fact producers generally fail to recognize and thus in many areas continue marketing practices which offer little opportunity for improvement of returns. Surveys indicate that the nearer an agency is to the terminal market in the marketing steps from producer to consumer, the larger is the percentage of eggs it buys on grade from the producer. Also the better it is equipped to maintain quality after eggs are purchased, the larger is the percentage of eggs it buys on grade.

The number of grades used ranges from two to five to producers while more may be employed in grading for wholesale markets. A survey of grading methods in 1932 indicated that 50 grade designations were being used. Less variation in grades and methods exists today than in 1932.

Two and three grades are most popular for purchase of eggs from producers. While two grades were preferred in 1932 by buyers, three grades are now most popular, lessening the need for rehandling and being more closely correlated with the market specifications.

A need for clearer definitions of grade names and specifications is indicated. The wide differences in grades and terminology confuse farmers seeking the best market for their eggs and also is confusing to competing buyers.

Grading live poultry

Poultry grading for quality has been practiced only in isolated cases, although poultry has been classified according to weight for several years in Iowa. Turkeys are being graded in most cases either alive or dressed when purchased from producers. In 1936 the first voluntary State-wide attempt was made to develop uniform quality grades and weight classifications in assembling of poultry from farms. Two quality grades were adopted designated as No. 1 and No. 2, somewhat similar to the Chicago live poultry board grades. The simpler quality grades were adopted rather than more complex grades which could be directly correlated with the three dressed quality grades used by most plants. It was felt that in such a new program the industry would more quickly adopt and have a better understanding of quality by proceeding from the simpler to a more complex grade after a better understanding had been acquired by both producers and buyers. The physical handling of the live bird was another factor considered in developing a simple grading program, for the type of buyers and the assembling practices in effect would have hindered rapid adoption of complex grades. Little effort was made toward adopting uniform weight classifications at an early stage of the grading program but it has become evident that the success of quality grading is dependent upon uniformity in the weight classes because of the difficulty of maintaining a uniform price structure while differing weight classes are in effect within a community or an area. Lack of correlation between the weight classifications in the live poultry market at Chicago and the New York dressed poultry market, which largely influence Iowa prices, has hindered adoption of uniform weight classifications to accompany quality grades.

A survey of weight classes used in Iowa during 1936 showed about five buying classifications in use for fowl and about six for chickens.

Buyers reported a trend toward purchases of fowl and chickens on a weight class basis of over 5 pounds, over 4 to 5 pounds, and 4 pounds and under 4 pounds although a classification of 5 pounds and over, 4 to 5 pounds and under was used in the majority of cases.

At an early stage of the market movement of chickens in the spring and summer, weight classes were either ignored or were started at weights of 2 pounds and under 2 pounds, or of 2½ pounds and under 2½ pounds, increasing the weight minimums as the majority of birds reached heavier weights or as the terminal market prices varied for different sizes.

The differentials between the two quality grades used, ranged from 1 to 6 cents, the majority of buyers reporting a 4-cent differential between quality grades of poultry.

Differentials between weight classes showed wide range but the majority of buyers reporting maintained a 2-cent margin, a smaller number using a 3-cent differential.

The attitude of market agencies processing poultry and also of producers is generally favorable to uniform quality grades for poultry. Adoption depends upon education of those engaged both in production and in marketing so that uniformity of methods will be maintained and a true reflection of market demands be established. Competitive practices appear to be the greatest hindrances to adoption of grades by any large segment of buyers in this producing area.

FACTORS AFFECTING MARKETING COSTS

Before the advent of motor-truck transportation, Iowa poultry and eggs were marketed to a considerable extent through local freight and express shipment to nearby markets. During this earlier period increasing numbers of plants were built, most of which were designed to handle a large volume obtained over a wide area, and to afford sufficient capacity for heavy seasonal marketings. Margins in transportation, assembling, and processing enabled such plants to be operated with larger unit costs than would be practical at present.

Changes in transportation and increasing numbers of buyers have had a marked influence upon assembling by processing plants and by shippers. Plants built before changes in transportation had occurred, or production had increased, and representing large investments are today at a disadvantage in competition with buyers having low overhead costs and operating in smaller areas of supply. The investment cost per unit of produce handled has been reduced in the smaller plant investments, and the reduced assembling costs of most small plants overcome the advantage of the lower processing costs of the larger plants.

Processing plants are at present assembling produce from smaller areas than was true a few years ago. The development of more involved processing and handling of poultry and eggs is likely to increase the use of the larger plants. The assembling of small lots of these products will facilitate economies in transportation and will permit large scale operations in processing these products. Sale by producers direct to processors and shippers has advantages in reduction of costs. Lack of knowledge of their best opportunities in marketing explains some of the indifference of producers to use of the more direct marketing methods. The trend toward greater contact with processing plants should increase the opportunity for producers to secure information of market methods, costs, and preferences and thereby will increase their opportunity to exploit their opportunities.

Market services in this industry are being expanded, as a result of producer demands, of competitive measures, or of the requirements of the market. The additional market services inevitably increase the cost of handling such commodities as poultry and eggs. Truck service to producers, particularly in small lots, is an added cost although it may result in better quality through more frequent marketings. More grading of eggs and poultry results in increased handling costs to the initial buyer, although it enhances values and reduces subsequent handling through the market channels, which overcomes the added handling costs in the primary market.

Improved packaging and processing of poultry and eggs will increase consumer demand but their first effect is increase in the cost of marketing.

The function of processing poultry and eggs in Iowa packing plants has been characterized in recent years by the following conditions which have increased some costs of processing and reduced others.

1. Fattening stations in processing plants showed progressively lower feeding gains after 1925 because of the greater incidence of particular diseases and changed feeding methods on farms. The gains formerly secured largely canceled the weight shrinkage sustained in dressing poultry (loss of blood and feathers). With lower fattening gains, costs of dressing shrinkage had to be taken out of the price to the producer.

2. The cost of dressing poultry was reduced within the past 15 years from a picking cost of 5 to 6 cents or more per head of chickens to costs ranging from $1\frac{1}{2}$ to 3 cents per bird through use of the semiscald and waxing method as contrasted with the former "dry picking" method. Along with this lowered cost there was an improvement in the technique of bleeding and removing feathers.

3. Higher standards of quality and improved packaging of dressed poultry packs now characterize Iowa marketing methods. The preparation of quick frozen poultry and of drawn poultry for market also increased interest in the preparation of more attractive market products.

4. Transportation improvements speeded movement to market by railroad and truck hauls.

5. Increased preparation of frozen liquid eggs and preservation of quality of shell eggs broaden the potential market.

6. Improved refrigeration methods to maintain the original quality of eggs and poultry in storage.

Local marketing costs and methods

Study of marketing costs and methods in a number of Iowa processing and shipping plants was undertaken in 1937 to determine the problems and methods involved in handling Iowa's annual poultry and egg crop through market channels in the State. Annual and monthly data regarding plant costs, methods, and results were secured from 20 plants during part or all of a 3-year period 1935 to 1937. While the data has been secured from plants representative of processing plants in the State and present the general aspects of costs incurred, no attempt has been made in this study to detail the exact factors giving rise to variations in costs.

While the initial price to the producer is the largest item of cost of the product to the buyer, the marketing costs, whether controllable or uncontrollable are most important in determining the buyer's competitive position, his ability to return to the producer a value based on market returns, and to assure a profit to his operations.

Assembling costs bulk large in the costs of marketing in nonspecialized producing areas. Assembling costs for both poultry and eggs are extremely variable due to differences in methods employed, among which are purchases from independent dealers, buying stations, commission buyers, truck routes to dealers or producers, or direct deliveries by farmers. Thus salaries, wages, and commissions, feed for poultry where furnished, telephone, rent, drayage and truck expense, coop or case costs, water, light and heat, insurance, taxes, interest and exchange, shrinkages and shortages, grading losses, and minor costs are involved to a greater or lesser degree in the various types of assembling.

The assembling methods used by processing or shipping plants in Iowa have shown a trend within recent years toward a price basis on deliveries by producers or the payment of a delivered price to subdealers upon receipt of products at the plant.

The program of many plants at present is to maintain a price at the plant above prices in surrounding towns or villages, or prices at the farm.

Where commissions to local buyers in the past were $1\frac{1}{2}$ cents above the farmer price for poultry at plants and 1 cent per dozen for eggs, local buyers at other than processing points, are in many cases paying producers $\frac{1}{2}$ to 1 cent less per pound for poultry than the plant price. Delivered prices paid to dealers at the plant are at or slightly above the producer price paid at the plant.

Not all the plants have adopted the delivered basis; some of the plants in the State use a basis of payment at the time and place of sale exclusively, while others use a combination of the two methods of payment to subdealers. The margins which are allowed for assembling by the 20 Iowa plants reporting in the present study are from 10 to 20 cents per 30-dozen case for transportation of eggs, depending upon length of haul, size of loads, and other factors.

The buyers are usually allowed from 10 to 15 cents per case for their cost of delivering eggs, plus their usual buying commission of 15 cents per 30-dozen case for handling eggs. Where eggs are graded by subdealers on specifications of the central plant an additional 15 to 30 cents per case is usually granted.

Where poultry is purchased from subdealers upon a track basis, the dealer is usually paid 1 cent over his paying price to the producer. A margin allowed for trucking by either plant-owned trucks or dealer-owned trucks is from ½ to 1 cent per pound depending on length of haul.

Hauling shrinkages are a considerable item in handling of poultry. Shrinkage in poultry purchased on a track basis may be from 1 to 10 percent or more depending on time and distance of haul, climatic conditions and condition of the poultry. The usual shrinkage incurred in transportation of poultry is 2 to 3 percent.

COSTS AND MARGINS IN PROCESSING POULTRY

Poultry may be shipped as live poultry or it may be processed, packed, and shipped as dressed poultry to the terminal market. The plants surveyed supplied data entirely upon dressed poultry, since live poultry shipments are a negligible part of their operations.

The expenses of a poultry plant include the receiving and feeding labor, feed and feeding-station supplies, dressing and refrigeration, packing and loading, packages and supplies, miscellaneous supplies and the plant overhead items of maintenance, light, heat, power and water, taxes and insurance, licenses, office supplies and salaries, administrative, and operative expenses. The scale of wages paid to labor in most of the plants reporting was considerably above that of the average for the industry.

Receiving costs for poultry involve the labor of unloading, sorting, and inspection of poultry for marketability and feeding ability. Receiving costs are relatively small and were not kept distinct for the plants reporting since most processing plants were more concerned with efficiency of receiving than its cost. This department has one of the most important functions in the plant and requires the most skilled persons available. Proper classification of poultry as to grades and the rejection of birds unsuitable for market are two functions in receiving operations which are of great importance to market agencies. The survey showed that for the 3-year period 1935–37, the percentage of worthless birds which escaped the notice of buyers and were discarded in the packing department was 0.4 percent of the fowl and 1.6 percent of the chickens purchased.

The fattening station expends a larger combined sum upon feed and other ingredients, supplies and labor, than any other department of the processing plant. The amount of feeding costs incurred depends upon the size of poultry, the length of time fed, and the number of birds fed.

Higher costs are found in feeding chickens than fowl largely due to the longer feeding period and the lighter weight per bird. During the 3-year period chickens showed better gains and better net yields than fowl (table 5).

Feeding gains in plants have been markedly reduced in recent years because of the greater incidence of diseases which affect the bird's ability to consume feed over a long period, the tendency for farmers to finish poultry with soft feeds before selling, and because of the numerous handlers intervening between producer and fattening station, which undoubtedly lowers the vitality of the bird and its response to feeding. The size, type, and maturity of poultry as well as climatic conditions at the time of market movement have much to do with fattening results.

TABLE 5.—*Feeding results and costs in 14 Iowa plants, 1935-37*

Item	Fowl		Chickens	
	Range	3-year average	Range	3-year average
Feeding costs, per pound, cents	0.45- 1.78	0.89	0.46- 1.78	0.99
Feeding gain, percent	5.2 -10.0	6.08	3.0 - 9.37	6.4
Average feeding period, days	2.6 - 7.0	4.68	2.9 - 6.83	4.9
Net yield, percent	91.7 -97.3	94.9	90.5 -104.5	96.7
Average dressed weight, pounds	4.6 - 5.3	4.7	2.2 - 5.3	4.3

TABLE 6.—*Costs of dressing poultry in Iowa plants, 1935-37*

Cost	Fowl		Chickens	
	Range	Average	Range	Average
Labor, per pound, cents	1.48- 2.10	1.81	1.59- 2.50	1.78
All dressing costs, per head, cents	2.05- 3.64	2.71	2.05- 3.87	2.64
Dressing shrink, percentage	11.4 -13.80	12.99	12.4 -15.20	14.40
Costs of dressing shrink in terms of meat value, per pound, cents	1.97- 4.02	2.17	1.79- 2.89	2.50

The net yield is the criterion most used in measuring the feeding gains, as it represents the pounds dressed and packed in relation to the pounds of live poultry purchased. Chickens show a higher net yield than fowl.

The dressing of poultry involves the killing, bleeding, scalding, waxing, and picking operations. No data were secured upon eviscerating, because few plants in the State were preparing drawn poultry and their operations were in a developmental stage.

Aside from the cost of labor and operation of machinery and of supplies the cost of dressing shrinks are an important item in processing costs (table 6). The dressing shrinks in the plants reporting indicate relatively high dressing shrinkages (loss of blood-feathers) due to the general practice of removing crop contents rather than holding birds off feed before killing.

Marked reductions in costs in dressing operations have been secured during the past few years because of increased mechanization of equipment and increasing skill in the dressing technique used. Most plants in this study used the wax process, and all used the mechanical semiscald method in their dressing of poultry.

Budgets adopted by some organizations are approximately $2\frac{3}{4}$ cents per head for picking costs where wax is used, and $3\frac{3}{4}$ cents where wax is not used.

The final plant processing operation includes grading and packing, container costs and refrigeration.

Packing costs and container costs vary considerably in respect to sizes and weights of birds. The cost per pound for packing and packaging is proportionately less for larger than for smaller size birds (table 7).

TABLE 7.—*Costs of packing and packaging poultry per pound in Iowa plants, 1935-37*

Cost	Fowl		Chickens	
	Range	Average	Range	Average
Packing labor, cents	0.11-0.33	0.19	0.09-0.25	0.17
Container cost, cents	.33- .60	.43	.31- .57	.49

TABLE 8.—*Cost of refrigerating poultry, per pound, in Iowa plants, 1935-37*

Cost	Fowl		Chickens	
	Range	Average	Range	Average
Refrigeration, cents	0.10-0.75	0.33	0.10-0.54	0.31

Refrigeration costs show much variation between plants due to the relation between investment in such facilities and the volume of product handled. The variation in costs occurs seasonally because of the shipping of frozen or chilled poultry. Thus during the fall and winter season when poultry may be shipped fresh (chilled only) cost is lower than at other periods of the year. Fowl shows a slightly higher cost of refrigeration per pound due to the fact that during the heavy movement of fowl, the cost of refrigeration is greater than with chickens marketed during the fall months (table 8).

Overhead and administrative costs reported show a range from 1.18 cents to 2.87 cents and an average of 1.20 cents in plants reporting. The relation of volume to overhead costs is reflected in the higher or lower margin needed between prices to the farmer, and market value. The year 1937 showed appreciably higher overhead costs, which were attributed principally to the lower volume but also to increased taxes and increases in some miscellaneous items.

Costs to handle and process dressed poultry through the processing plants are quite variable, depending upon plant investment charges applied, assembling methods used, the volume and type of products handled, and the amount of processing involved. During the 3-year period 1935-37 the purchases of 18 poultry plants per plant varied from 202,701 pounds to 1,572,234 pounds annually, with an average of 697,629 pounds. The proportions of the types of poultry purchased are indicated in table 9.

TABLE 9.—*Type of poultry purchased by 18 plants, 1935-37*

Type	Range	Average
	Percent	*Percent*
Fowl	30.4-53.6	42.4
Chickens	31.4-61.4	50.1
Old roosters	1.0- 5.1	2.9
Turkeys	.0-12.8	2.3
Ducks and geese	.1-10.9	1.8
Miscellaneous (not defined)	.0- 8.9	.5

TABLE 10.—*Percentage of poultry of highest grade packed by 15 plants, 1935-37*

Type	Range	Average
	Percent	*Percent*
Fowl	67.1-90.2	80.6
Chickens	35.4-83.7	62.3

TABLE 11.—*Percentage of birds packed in highest grade, monthly, 1935-37*

Type	Jan.	Feb.	Mar.	Apr.	May	June
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fowl	85.5	87.3	82.0	84.7	80.3	83.4
Chickens	51.1	37.6	25.7	47.0	78.8	79.9

Type	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fowl	84.0	81.4	79.3	77.0	81.9	85.6
Chickens	81.9	76.0	72.7	69.1	62.6	61.0

QUALITY OF POULTRY MARKETED

Each plant processing poultry has an established brand and standard of quality in its pack. While the standard of quality may vary between plants the stability of poultry packs is maintained because of competitive selling conditions in the distributing market, and established trade practice.

The percentage of highest grade birds box-packed for shipment in the 15 plants reporting, reflect the quality of receipts packed in Iowa during the period 1935-37 inclusive (table 10).

The wide range of highest quality grades packed indicates some variation in the standard of quality used, as well as the quality of poultry received.

The quality of fowl shows its greatest decline during the period from August to November and the highest percentage of quality fowl packed was reported from December to April during the 3-year period (table 11).

Quality of chickens was highest in the period of low receipts during the early stages of market movement from May to September. Part of the abrupt decline from November on is due to stagginess of cockerels.

The grading losses sustained by producers in Iowa are logically reflected in a lower price level where poultry is not purchased on grade from farmers. While improved quality of receipts might help to widen the margin for the buyer, increased competition for such quality products lessens the likelihood that where poultry is of a superior quality, the margin between farm and market will be lowered where higher quality poultry is marketed (table 12).

TABLE 12.—*Grade percentages and cost of grading loss, 1935-37*

Grade or class	Fowl		Chickens	
	Proportion	Price differential from highest grade	Proportion	Price differential from highest grade
	Percent	*Cents per pound*	*Percent*	*Cents per pound*
First	80.6	....	62.3	....
Second	14.2	1½- 2	26.3	1½- 2½
Third	4.8	4½- 6	7.7	4½- 6
Stags	....	....	2.1	3 - 6
Worthless	.4	12 -18	1.6	12 -18

The grading loss per 100 pounds of fowl averaged $0.584.
The grading loss per 100 pounds of chickens averaged $1.26.

DRESSED POULTRY MARKETING COSTS BETWEEN THE FARM AND TERMINAL MARKETS

The cost of the marketing functions performed by producers has been estimated by Benjamin[2] as from 0.05 cents to 1.5 cents for marketing live poultry. No costs were secured in the present study of the producers' actual cost of marketing.

The plant processors' costs of handling poultry for dressing, as determined from the reports of plants in this study, are shown in table 13.

During the period in which this study was made (1935-37) there were extreme variations in volume of poultry marketed. The years 1935 and 1937 were years of relatively low production while the year 1936 was characterized by record marketings. This variation in volume marketings partially accounts for the wide range in costs during the 3-year period.

"Normal" or maximum freight rates, including icing charges, upon a net basis to New York from the 20 plants reporting as of July 1, 1938 varied from $1.44 to $1.64 per 100 pounds of poultry. In Chicago the rate varied from 68 to 94 cents per 100 pounds on a carlot basis. Temporary rates were appreciably lower than the maximum rates, ranging from 1 to 5 cents per 100 pounds lower to the New York market and proportionally lower to Chicago.

Six plants reported total costs of processing turkeys through the plants ranging from 2.48 cents to 5.73 cents per pound. The average cost of processing averaged 4.09 cents per pound. Many plants in the State now handle turkeys on a consignment basis, or on a basis of a certain fixed margin under the markets on a dressed grade. Such margins vary from 3.75 cents to approximately 5.00 cents per pound. Producers in such instances are paid on a basis of dressed turkey grades directly correlated with market grades. Shrinkages and grading losses are assumed by the producers.

Where turkeys are purchased on a live ungraded basis the margins under the market may be from 5 to 9 cents per pound depending on quality, service of assembling provided, and the distance of the processing plant from the market.

TABLE 13.—*Marketing costs between farm and terminal markets of dressed poultry*

Cost	Range	Average
	Cents per pound	*Cents per pound*
Assembling live poultry	0.10- 2.00	1.00
Processing and plant costs	4.14- 7.01	5.62
Freight to New York (normal rate as of July 1, 1938)	1.44- 1.64	1.48
Freight to Chicago (normal rate as of July 1, 1938)	0.68- 0.94	.71
Cost to the New York market	5.68-10.65	8.10
Cost to the Chicago market	4.92- 9.95	7.33

LIVE POULTRY MARKETING COSTS TO THE NEW YORK MARKET

Shipping and handling costs for live poultry from Iowa to such a market as New York are approximately the same as those estimated for marketings from producers in Missouri to New York City[3] (table 14).

Marketing costs for live poultry in country points are appreciably lower than for dressed poultry. However, there are economies in processing poultry in the surplus producing section, which have reduced the volumes being shipped alive from Iowa to New York in particular. While Chicago receives considerable live poultry by motor truck from Iowa, the handling charges and instability of live poultry marketing conditions, maintain at a rather fixed amount the shipments of poultry marketed in this manner. Such live poultry as is shipped, is marketed for holiday periods or at seasons of short supplies.

Lower labor and processing costs and lower

[2] Benjamin, Earl W. Marketing Poultry Products. John Wiley & Sons, Inc. 1923.

[3] United States Dairy Association Misc. Publication 283. Economic survey of the live poultry industry in New York City. Table 26, Page 73.

freight haul costs, as contrasted with the high costs of processing in terminal markets, and the usually favorable relationship of dressed poultry markets in respect to live poultry markets have also been among the influences decreasing the percentage of poultry marketed alive from Iowa.

Live poultry costs by truck to interior consuming centers where the principal shipments of live poultry are made have not been surveyed in the present study. The Chicago market has advantages for shippers of live poultry during certain seasons of the year—notably during the late winter and spring for light fowl, during Jewish holidays, and during the early stage of the chicken movement each spring and summer.

The disadvantages (to producer and shipper) of live poultry marketing have been stated by Stockard[4] as "(1) the highly perishable nature of live poultry and inability to carry it for any great length of time after arrival at the market, which means radical fluctuations in price under excessive supply; and (2) the transportation hazards affecting the health and well-being of live birds."

TABLE 14.—*Estimated costs of marketing poultry from producers in Missouri to retail in New York City*

Item	Cost per pound
	Cents
Price received by Missouri producers	15.0
Procurement cost, buying and trucking	2.0
Cost of country plant operation, including shrinkage	.6
Freight	1.3
Carman	.5
Feed	.6
Unloading	.3
Coops	.4
Trucking at New York City	.3
Commission	1.0
Slaughtering including shrinkage and trucking	4.0
Delivery and bad debts	.5
Total	27.0

U. S. Dept. of Agric. Misc. Pub. 283.

COSTS OF GRADING AND HANDLING EGGS

Important developments have occurred in the handling of eggs in this area as indeed throughout the nation. Eggs in the shell continue to be the principal form in which eggs are merchandised from Iowa, although the preparation of frozen liquid eggs and also the oil coating of the finer grades of egg show an increase over former years. Breaking and freezing of eggs have helped to reduce distribution costs and lessen breakage and quality deterioration of shell eggs moving through market channels.

The shell eggs arriving at the plants are mostly ungraded and in used containers. The shipper must provide new cases, grading, and cooling in addition to transportation and distribution costs, which are considered in basing prices in the local market.

Shipping plants in most instances market quality grades of eggs with their own brand name according to market specifications for grade. Many buyers also market eggs in terminal markets as rehandled receipts or as current receipts either seasonally or during the entire year.

In the marketing of shell eggs, comparisons between plants in country sections are difficult owing to the nonuniform character of grading, and methods of handling.

The cost items in the plant involve the labor of receiving the eggs, candling, packing, the packages and supplies, maintenance, electricity, refrigeration, and the items of office supplies and salaries, licenses, taxes, insurance, interest, and administrative costs.

New egg cases and fillers are required by railroad tariff regulations and these costs ranged from 30 to 40 cents per 30-dozen case during the period surveyed (1935–37).

Eggs are purchased from producers on a basis of new or used cases included, or on a case-returned basis when purchased from subdealers and producers. Producers usually retain their cases, particularly when marketing in less than 30-dozen case lots.

The egg case cost assumed by the industry in Iowa and other areas distant from markets is higher than for points adjacent to markets where low cost second-hand cases, costing from 5 to 20 cents each, can be used.

Refrigeration, power and light, and other items in handling eggs also show considerable variations between plants annually and seasonally. Refrigeration varied for the 3-year period from .03 to .32 cents per dozen in the plants reporting. Power and light costs varied from 0.01 to 0.17 cents per dozen. While this extreme variability in these costs may be in part due to differences in accounting methods used, the difference largely represents use of these facilities and extent of grading involved.

Overhead items in plants reporting varied from 0.53 to 1.75 cents per dozen. Plants reporting higher overhead costs handled only a small volume of eggs.

The plants were in many cases combination plants in which butter, poultry, and eggs are handled. Overhead costs applied to eggs may be excessive in many such instances, since space for handling eggs requires but a small investment and less refrigeration than poultry. In most plants the space allotted to poultry processing is the largest part of the plant investment. If eggs only were to be handled the investment requirements would be much decreased. A proper distribution of the investment costs to eggs is difficult and often the proportion of such costs allotted to eggs may be at variance with the real costs involved.

[4] Stockard, F. L., in U. S. Egg and Poultry Magazine, August, 1933, p. 26.

The costs involved in grading, candling, and handling of eggs in the 13 plants reporting, are considered typical of costs of shippers of eggs (table 15). While marketing costs of producers were not secured in the present study, such costs are estimated to be approximately ½ cent when eggs are sold to grocery stores; ½ cent to hucksters; 2 to 3 cents per dozen to consumers, and in shipment to eastern markets, 3 to 4 cents per dozen. The sale of eggs direct to consumers in local markets is limited, while only commercial producers can ship to eastern markets because of quality produced or quantity to be shipped.

TABLE 15.—*Marketing cost between farms and terminal market of eggs*

Cost	Range	Average
	Cents per dozen	*Cents per dozen*
Assembling	0.08-1.50	0.75
Candling cost	.19- .57	.38
General labor, etc.	.07- .40	.10
Cases	1.00-1.33	1.17
Refrigeration	.03- .32	.10
Electricity, power, etc.	.01- .17	.04
Supplies	.00- .10	.03
Overhead	.53-1.75	.79
Freight to New York (normal rate as of July 1, 1938)	2.33-2.63	2.43
Freight to Chicago (normal rate as of July 1, 1938)	1.10-1.50	1.18
Cost to the New York market	4.24-8.77	5.79
Cost to the Chicago market	3.01-7.64	4.54

"Normal" freight costs July 1, 1938 varied from 2.50 to 2.67 cents per dozen from the plants reporting, including icing to New York while Chicago "normal" rates were 2.9 to 4.7 cents. Temporary rates in effect as of that date were considerably under the normal rate.

SUMMARY

Iowa's organization for production and marketing is typical of that of the farm-flock producing area, which is the predominant source of supply for the annual crop of poultry and eggs in the nation.

The area of which Iowa is a part has a large number of farms upon which poultry is found as only one of a number of enterprises. Physical and economic factors have been favorable to development of poultry production on most farms and it is regarded as a necessary part of the farm enterprise.

Seasonality of production and farm marketings, selling practices, and the market characteristics of the products produced have been the general influences determining marketing methods of Iowa and other Midwestern States.

While poultry production is more flexible than most livestock enterprises, the producer's response to market and price factors is not as great as in areas where production may be more specialized.

The economic problems involved in marketing poultry and eggs from the State involve considerations of decreasing seasonality of marketings, greater uniformity of quality, and efficiency in the assembling function. Competitive influences of a large number of buyers have handicapped efforts toward standardization in assembling and grading methods.

Variability in costs between market agencies is wide, as differing methods of assembling and processing are used by plants having greater or smaller investments, or as they are influenced by the type and nature of production or competitive practices in a particular area.

Changing means of transportation, newer methods of processing, and improved production methods are causing an unstable situation in the marketing of poultry and eggs in Iowa and the middle western area at present. Production will change as the impacts of market demands are felt by producers and market agencies though changes are likely to be slower than in specialized production areas.

AN ECONOMIC ANALYSIS OF COOPERATIVE POULTRY MARKETING IN THE UNITED STATES

By JOHN J. SCANLAN, *Senior Agricultural Economist, Cooperative Research and Service Division, Farm Credit Administration, Washington, D. C., U. S. A.*

Cooperative marketing of live and dressed poultry in the United States has been tardy. Although it has shown continued growth and development, as compared with the cooperative marketing of most other important agricultural products, including eggs, the cooperative marketing of poultry has not reached important proportions except in the case of turkeys.

Two underlying factors have caused the growth of cooperative marketing of poultry to be relatively slow; these are: (1) The widespread nature of poultry production and (2) the need for a large amount of processing in the handling of dressed poultry.

In 1935 chickens were raised on 85.6 percent of all farms in the United States. However, in 1929, on only 2.6 percent of the farms was poultry the chief source of income. On most of the farms poultry production is merely a minor and side-line enterprise or a byproduct of egg production.

The bulk of the poultry is consumed locally and in only a few relatively small areas is there sufficient concentration of production to result in a regular surplus requiring disposition in distant markets. Consequently, producer-interest in the need for and the benefits of improved marketing methods and practices has in only a few instances become of sufficiently important community interest to result in the setting up of cooperative associations to market live or dressed poultry.

Farmers' cooperative associations have been, generally speaking, most successful in the handling of those products which require relatively little complicated processing and which are at the same time not perishable. Live poultry is very perishable; dressed poultry is not only very perishable but it requires unusual skill in processing and the use of costly dressing and packing plant facilities. To operate such plants requires considerable capital and sufficient and steady volumes of poultry receipts to keep the unit costs low. Because of the very scattered nature of our poultry production, volumes sufficiently large to utilize and maintain dressing and packing establishments must usually be assembled over a wide territory, thereby creating a procurement cost to be borne by the producers. A further difficulty arising from the seasonal nature of poultry marketing is that of keeping the plant and equipment adequately utilized for low-cost operation. The handling of eggs as well as poultry helps to give fuller utilization to plant facilities and to personnel throughout the year.

CAUSES FOR DEVELOPMENT

No one or even several marketing practices or methods can be pointed out for the nation as a whole as being the primary causes for the development of cooperative marketing of poultry or as being specific problems which were to be solved by such cooperative effort. There were usually a number of these, often closely interrelated and different for the several distinctly different production areas. A growing dissatisfaction with prices for poultry, attributed largely to existing marketing methods, outlets, and agencies, and the gradual growth of cooperative marketing of other farm products, especially of eggs, were no doubt potent causes. A feeling of a lack of actual competition between buyers in the procurement areas, the general practice of buyers to pay the same price for poultry without regard to quality, the opinion of the producers that the spread between the farm price and the terminal market or consumer price was too wide, and the desire for collective and orderly marketing were other important causes. In some areas unethical practices of buying poultry at the farm were common. These included the giving of bad checks, improper grading, excessive discounting for defects, and dishonest weighing. Buyers and market outlets often were undependable financially and otherwise. The producers desired and hoped to obtain through cooperative effort continuous and dependable market outlets which would enable them to secure prices commensurate with quality and as close to the terminal market prices as low-cost nonprofit operation would make possible.

STATUS OF THE MOVEMENT

Although poultry was marketed cooperatively in a few areas prior to 1920, the volume sold in this manner was very small. Since 1920, and particularly during the last decade, the movement has gained considerable momentum and in some sections has become important. Aside from turkeys, however, there have been few instances where associations have been organized strictly as poultry-marketing associations. Generally, poultry is handled by associations originally formed to market eggs or some other commodity or to purchase farm supplies.

A survey made by the Farm Credit Administration showed that in 1936 there were 576 cooperative associations marketing poultry in the United States. (See table 1 and figure 1.) Of this number only 91 can be classed as poultry or turkey associations by virtue of the fact that more than 50 percent of the total value of the produce handled by them was poultry or turkeys. Of these 91 organizations, 72 were strictly turkey-marketing associations, while the remaining 19 were principally associations marketing chickens.

Most important in the cooperative marketing of poultry are the associations other than egg and poultry associations organized originally to market or process other agricultural products or to purchase farm supplies. This group, numbering 454 associations, handled 32.6 percent (in terms of the sales value) of all poultry marketed cooperatively in the United States in 1936. The value of chickens handled accounted for 95 percent of the total sales of $5,371,800 of these associations.

Of almost equal importance are the egg- and poultry-marketing associations organized primarily to handle eggs but which handle poultry as a complementary product. These associations, numbering 31, handled 31.5 percent of the value of all poultry marketed cooperatively in 1936, of which 70 percent constituted the value of chickens and 30 percent, turkeys.

The value of poultry marketed by the 576 associations approximated $16,500,000, equal to slightly more than 27 percent of the total value of all poultry products marketed cooperatively in the United States in 1936. Turkey sales totaling $5,806,000 constituted approximately 35 percent of all poultry sales. Of the remaining 65 percent, the 19 associations classed as poultry associations handled only $1,794,000 of sales or 11 percent of all cooperative poultry sales.

Turkey associations handled an insignificant volume of chickens but were the principal handlers of cooperatively marketed turkeys. They sold 70 percent of all turkeys and 25 percent of all poultry marketed cooperatively.

TABLE 1.—*Cooperative poultry-marketing associations: Number of associations and sales value of poultry marketed, by type of association, 1936*

Type of association	Number of associations	Value of poultry marketed (other than turkeys)		Value of turkeys marketed		Total sales value	
		Amount	Percentage of total	Amount	Percentage of total	Amount	Percentage of total
		Dollars	*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*
Poultry	19	1,794,100	16.8	....	....	1,794,100	10.9
Turkey	72	76,700	.7	4,042,000	69.6	4,118,700	25.0
Egg and poultry	31	3,703,400	34.7	1,490,700	25.7	5,194,100	31.5
Other cooperative marketing and purchasing	454	5,098,500	47.8	273,300	4.7	5,371,800	32.6
Total	576	10,672,700	100.0	5,806,000	100.0	16,478,700	100.0

LOCATION AND TYPE OF COOPERATIVE ASSOCIATIONS MARKETING POULTRY IN THE UNITED STATES, 1936

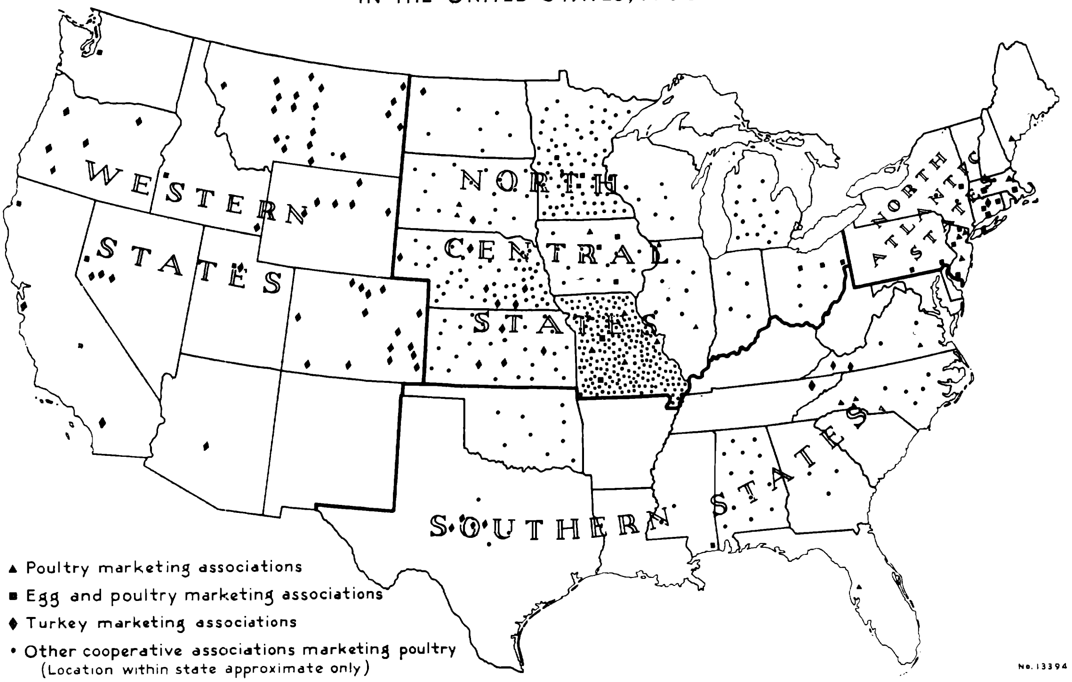


FIGURE 1.—In 1936 there were 576 cooperative associations in the United States marketing live or dressed poultry. Of these, 72 were exclusively turkey-marketing associations, 31 marketed eggs and poultry chiefly, and 19 marketed chickens principally. The remaining 454 associations marketed poultry as a side line only as they were organized originally and primarily to market other farm products or to purchase farm supplies. A large number of these 454 associations operate in Missouri as locals of a general farm business organization and in Minnesota and other North Central States in the form of cooperative creameries.

TYPE OF ASSOCIATION

Chiefly because of the large size of the country, with the resulting variety of production and marketing conditions, the importance of the cooperative marketing of poultry and the types of associations doing this marketing vary widely among different areas. As is true also of eggs, the cooperative marketing of poultry has reached its most important development in the heavier commercial production areas. Cooperative marketing is done by associations generally different in type in the North Central, Western, North Atlantic, and Southern areas. As stated above some of these types of associations handle poultry or poultry products exclusively; others market these products in conjunction with the marketing of other farm products or as a side line in the handling of farm supplies.

The 12 North Central States contained more than 76 percent of all cooperative associations marketing poultry in 1936 (tables 2 and 3). However, the value of poultry handled accounted for less than 46 percent of the total value marketed cooperatively in the country in 1936. Of the 442 associations located in these States only 21 can be classed as strictly poultry organizations and 12 of the 21 are turkey-marketing organizations. Eleven were egg-marketing associations handling poultry as a complementary product while 410 were other cooperatives engaged primarily in marketing other than poultry products or in the purchasing of farm supplies. The bulk of the poultry marketed cooperatively in the North Central States is handled by a relatively few large associations which operate dressing plants where the poultry is dressed, graded, and packed for shipment. The majority of those handling poultry in the North Central area are small and local in area of operation. The type of poultry handled is largely that of the heavier meat breeds typical of the farm-flock area as contrasted to more of the lighter egg type breeds in the North Atlantic and Western areas.

The second area of importance in the cooperative marketing of poultry are the 11 Western States. Seventy-five percent of the turkeys marketed cooperatively in 1936 were handled by 52 turkey associations and 3 egg associations operating in these States. In addition to turkeys, 16.4 percent of the chickens marketed cooperatively were handled by the large egg associations operating in these States. The combined value of chickens and turkeys marketed in this area in 1936 accounted for 37 percent of all poultry marketed cooperatively in the United States.

The growth and development of cooperative turkey marketing in the Western States has been an outstanding feature of poultry marketing in this country. The development has followed closely the expansion of commercial production of turkeys in these States. It is estimated that in 1936 the cooperative turkey-marketing associations of the country handled from 15 to 20 percent of all turkeys sold. As already indicated most of these turkeys were handled by western cooperatives. These associations range in size from small local pools to district and regional organizations. All turkeys sold and dressed by them are graded according to U. S. Standards and Grades for Dressed Turkeys.

Poultry, other than turkeys, marketed cooperatively in the Western States is handled chiefly by the large egg associations operating in four

TABLE 2.—*Number of associations and value of poultry sold cooperatively in the United States, by geographic areas, 1936*

Geographic area	Number of associations	Value of sales					
		Poultry[1]		Turkeys		Total	
		Amount	Percentage of total	Amount	Percentage of total	Amount	Percentage of total
		Dollars	*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*
North Central	442	6,652,000	62.3	918,000	15.8	7,570,000	45.9
Western	62	1,752,000	16.4	4,356,000	75.0	6,108,000	37.1
North Atlantic	21	1,718,700	16.1	200,000	3.4	1,918,700	11.6
Southern	51	550,000	5.2	332,000	5.8	882,000	5.4
Total	576	10,672,700	100.0	5,806,000	100.0	16,478,700	100.0

[1] Not including turkeys.

TABLE 3.—*Type of cooperative associations, by geographic areas, marketing poultry in the United States, 1936*

Geographic area	Number of associations					Percentage of associations				
	Poultry[1]	Turkey	Egg and poultry[2]	Other[3]	Total	Poultry[1]	Turkey	Egg and poultry[2]	Other[3]	Total
	Number	*Number*	*Number*	*Number*	*Number*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
North Central	9	12	11	410	442	47.4	16.7	35.5	90.3	76.7
Western	0	52	6	4	62	0	72.2	19.4	.9	10.8
North Atlantic	5	1	12	3	21	26.3	1.4	38.7	.7	3.6
Southern	5	7	2	37	51	26.3	9.7	6.4	8.1	8.9
Total	19	72	31	454	576	100.0	100.0	100.0	100.0	100.0

[1] Includes only associations at which more than 50 percent of the total business constituted poultry sales, but excludes turkey associations.
[2] Includes associations handling eggs and poultry combined; eggs being the principal product.
[3] Includes other cooperative marketing and purchasing associations handling poultry as a minor farm product.

of these States. It consists principally of broilers and fowl of the lighter breeds. Dressing plants, operated in conjunction with the egg and feed plants of the egg pooling associations, dress and pack the birds for local and distant markets. One cooperative has been canning chicken meat successfully for a number of years.

The relatively small proportion of poultry marketed cooperatively by 51 associations in the Southern States is shipped, chiefly alive, to distant markets. The South, as a whole, is relatively unimportant in the marketing of eggs and poultry, and very little surplus of either product moves to outside markets. Although the most concentrated commercial broiler-production area of the country is located in the northeastern portion of the Southern States there is no record of successful attempts to market the product cooperatively.

In the North Atlantic States, the bulk of the poultry marketed cooperatively is handled by the producers' country-point egg and poultry auction associations. All poultry marketed by these associations is sold live at auction. It is of both the light and the heavy breeds. A duck association formed in 1916 has continued to operate ever since. It is the only duck association now operating although several others have been formed in the North Atlantic area.

ACCOMPLISHMENTS IN MARKETING

Although a relatively unimportant segment of the poultry-marketing industry as a whole, the cooperatives have made a number of definite and progressive contributions to the industry. Particularly is this true in areas where the cooperatives handle a considerable portion of the dressed poultry moving to market.

The associations handling poultry were generally first in establishing the practice of payment on the basis of quality. To facilitate this method of payment they early adopted specific grades and standards of quality in accordance with which the birds were classified. The Federal grades for turkeys have been adopted by most of the larger associations. Poultry auctions in the North Atlantic States formulated their own grades for live poultry which follow closely the Federal standards of quality. The ultimate effect of this practice was improvement of production practices and flocks in the area of receipts and the forcing of competitors to adopt similar payment and quality bases.

Closely related to the practice of paying on a quality basis has been the improvement of the pack of dressed poultry shipped to market. An outstanding example of this improvement can be found in the accomplishments of the western turkey cooperatives. By careful grading and dressing methods these associations, through a regional sales agency, have developed a pack of birds sold under Federal grades and with a brand name which has become known throughout the country as a mark of high and dependable quality.

In addition to improving the quality and pack of poultry the cooperative associations have been instrumental in lowering marketing costs. This has been accomplished through adoption of lighter packages; securing of freight reductions; establishment of efficient assembling and dressing plants; lowering of local and terminal costs and margins; and creation of district, regional, and terminal marketing agencies to handle the selling of the products of the local associations and to develop broader and more direct market outlets in the important consuming centers.

PROBABLE FUTURE OF THE MOVEMENT

The future growth of cooperative marketing of poultry in the United States will probably continue to be slow. Our producers feel a need constantly to improve marketing methods and agencies. However, the rate of growth may continue to lag behind that of the cooperative movement as a whole.

Most rapid growth may be expected where there appears to be the greatest need for market improvement. At present the heavy production area of the North Central States seems to present such a situation. It is to be expected that some pronounced development will occur in these States. When more suitable types of cooperatives have been developed to meet the conditions of this area the movement will undoubtedly progress more rapidly than in the past.

No doubt, associations already existing will continue to grow. The need for a closer working relationship and for a greater coordination of effort among the larger poultry-handling cooperatives, particularly the regional and terminal sales agencies, promises to be met in the near future.

SUMMARY

Cooperative marketing of live and dressed poultry has not attained in the United States as important proportions as that of eggs or many other important farm products and crops. In number, more than three-fourths of such associations are in the North Central States. The majority of them handle other commodities primarily. The Western States are second in importance, where the marketing of dressed poultry in conjunction with eggs through the large egg-pooling cooperatives and the cooperative marketing of dressed turkeys has reached important proportions. In the North Atlantic States live poultry is sold largely by local country-point auction associations, and in the Southern States it is shipped in carlots to the large eastern markets.

Although the volume handled by them has not been large relative to the total poultry production of the United States, these cooperative associations have made a number of important and progressive contributions to the marketing of poultry. A slow but continued growth in both number of associations and in the volume of poultry handled by the present associations is anticipated.

AN ECONOMIC ANALYSIS OF COOPERATIVE EGG MARKETING[1]

By JAMES M. GWIN, *Associate Professor, Department of Poultry Husbandry, University of Maryland, College Park, Md., U. S. A.*

The early records of cooperative egg marketing in the United States contain accounts of many discouraging experiences, failure having followed all of the initial cooperative ventures after comparatively short periods of operation. The first attempt to market eggs cooperatively was reported in 1874, the significance of this early date being minimized, however, by the cooperative's short period of existence and by its lack of permanent accomplishment. Apparently it failed to influence the organization of similar associations, for a period of more than a quarter of a century elapsed before another poultry products marketing cooperative was successfully established.

The first egg marketing cooperative to meet with any great measure of success was started in 1901 by a group of poultrymen on the Pacific Coast. During the next ten years organizations of a somewhat similar nature were started in the North East, the Middle West, and at other points on the Pacific Coast. In some cases these associations were of great value to their members and were continued as their sole marketing agency over long periods. Others, however, found operating conditions less favorable than anticipated and were soon discontinued. The reason for failure was generally given as lack of membership support, which in turn could frequently be traced to the cooperative's inability to make returns equal to those paid by competitive agencies. Occasionally failure was attributed to insufficient operating capital, lack of business experience on the part of the management, or a combination of part or all of these factors.

Practically all of the egg marketing cooperatives which are operating today have been developed within the past 20 years. During the early part of this period considerable progress was made all along the Pacific Coast and by a few isolated associations in other sections of the country. The eastern auctions, which are now an important part of the cooperative marketing in the East, have been developed within the past 8 years.

It is of interest to note that the egg marketing cooperatives which have attained the highest degree of success are located in the specialized production areas, namely, the Pacific Coast, the North Atlantic States, and to a lesser extent in sections of the Middle West. Although other parts of the country supply large quantities of eggs, they are mostly produced by small flocks on farms where egg production is regarded only as a side line in which there is not enough producer interest or volume of product of a quality needed to support a cooperative association.

It is the usual custom of cooperative associations in the poultry field to confine their early activity to the marketing of one product until they become established and have gained some experience in cooperative methods. When the demand for additional service can be met in a manner that will effect economies for all, the organization may expand its marketing activities to include all poultry products and it may establish a cooperative purchasing service for feed and supplies.

The purpose of a marketing cooperative is to provide the individual producer with an agency that can economically place his produce on the most favorable markets. Working through cooperative effort, producers are given the advantages of marketing facilities and services which they could not afford to use if marketing individually.

Cooperative egg marketing associations can justify their existence only by rendering to their producer members a more profitable or complete service than they receive through other marketing means. This must be done on an equal basis with other marketing agencies. For this reason it is highly important that egg marketing cooperatives be located only in areas where a need for their services has been definitely determined.

TYPES OF EGG MARKETING COOPERATIVES

During the growth of the cooperative egg marketing movement, associations of different types have been developed to meet the production conditions and marketing requirements of each particular area. Although there are minor differences between most of these types of cooperatives, it is possible to include them all under one of the following classifications: The cooperative egg pooling association, the cooperative auction association, the cooperative shipping association, and other cooperative associations marketing eggs.

The Cooperative Egg Pooling Association

The cooperative egg pooling associations are the oldest and largest of all egg marketing cooperatives. They consist primarily of a group of producers who establish facilities for receiving, grading, and marketing their product through channels of trade that can be reached most effectively by the cooperative pooling plan.

The name "pooling associations" applies to the basis and manner in which these organizations price the producer's product and the way in which they handle the eggs after they have determined the quality as received from their individual

[1] Technical Contribution No. 493, Maryland Agricultural Experiment Station, published by permission of the Director of the Maryland Agricultural Experiment Station.

producers. By pooling all eggs of like grade into one lot, the cooperative is given the advantage of offering on the market large quantities of eggs of uniform quality. Through this method the eggs of the members are offered to all buyers, some of whom may be interested in small lots and others in carlot quantities. The "pool price" of each grade is determined by averaging all sales of that grade for a given period. Returns to producers are based on the "pool price" for each grade furnished, minus the handling charge.

Differing from the auction method, the pooling cooperative must be able to assure a more dependable supply of eggs during all seasons of the year. For this reason annual membership agreements are normally required, which make it necessary for members to market through their association all eggs except those used for hatching or for home consumption.

In most cases the pooling associations are directed by a board of producer members who in turn choose a general manager and staff, they being charged with the responsibility of handling, grading, and selling, and other details of the business. Through the pooling type of organization, eggs can be sold to consumers, jobbers, or wholesalers in the nearby area or may be shipped to distant markets. In the local market it is sometimes possible to dispose of a portion of the product most advantageously by establishing a delivery system for retail stores and other outlets. Some pooling cooperatives have been able by the sales of cartoned eggs to carry their brand through to the consumer, thus establishing more firmly their position as a marketing agency. These associations usually receive higher gross returns for their eggs than other types of cooperative organizations, but varying portions of this extra price are needed to pay for additional services.

The establishment of a pooling cooperative requires a comparatively large initial financial outlay and considerable volume of product to cover the overhead required for efficient operation. The manner in which each association has been able to handle the problem of financing its cooperative through the early stages of development has determined to a large extent the chances of its becoming an established marketing agency.

A method which reduces the organization problem of egg pooling cooperatives has been sponsored by some of the large established eastern cooperative-purchasing agencies by adding to their organizations an affiliated egg marketing service. Aided by cooperative experience, operating capital, and established membership contact, these subsidiary organizations have developed into important market service agencies for the poultry interests in their area. Although these subsidiaries receive the benefits and advantages of membership in a larger organization, they must in return submit to the operating limits of the general policy of their foster organization.

The Cooperative Country Point Auction Associations

The marketings of eggs through cooperative auctions has developed largely in the North Atlantic States. This is a recent plan which has proven an economical means of moving the producer's product into profitable market channels. The first of the auctions now operating was established in 1930. Since that time 25 others, many of which handle poultry and in a few cases other agricultural products, have been organized at points in ten of the Northeastern States.

The egg auctions, like other cooperative selling organizations, are directed by a board of producer members who employ a manager or auction master to supervise all matters pertaining to the operations of the auction. The duties of the auction manager vary from the supervision of plant operations to the handling of buyer and producer problems.

The importance of location makes it highly desirable for egg auctions to be placed in the quality production areas near markets from which many buyers of the higher quality eggs may be attracted. The concentrating of all egg auctions in one comparatively limited area is explained by the importance of location in relation to the producer's supply and buyer outlet.

The rapid development of egg auctions has been due largely to the successful operation of the auction plan of economically performing for the producer only the essential wholesale marketing services needed for profitable distribution. The low-cost method of grading, which has received both producer and buyer approval, illustrates one of the methods that has enabled the auctions to render needed service at nominal cost. Realizing that the producer at the time of packing could materially reduce operating cost by grading his eggs for size, color, and cleanliness, the auction encouraged the adoption of this practice, which it further stimulated by identifying the producer's eggs at the time of sale with their permanent individual membership number. As an essential to continued buyer confidence it was found advantageous to assure uniform grade standards. To do this, auction inspectors, working under the supervision of a State or Federal grading authority, inspect the member's eggs as they are brought to the auction plant by candling a representative sample from each case to determine the final grade and weight designation under which they are to be offered at the following sale.

In addition to the auction's advantage of low operating costs, its appeal to the producer is increased by its practice of prompt payment, its simple and open method of sales, its operation under local control, and its freedom from marketing contracts. Under these conditions, however, it is placed in the position of depending to a large extent upon intangible assets which may be held only through the continuation of efficient operation.

The future of the egg auction method will depend largely upon its ability to maintain a competitive advantage in the marketing field. During the relatively short period in which auctions have operated they have shown a consistent growth, handling a volume that is now an important factor in the egg marketing field. A table compiled by the Farm Credit Administration,[2] shows the growth of the egg and poultry auction associations together with the number of associations, the active members, and the volume of eggs and poultry handled by years (table 1).

The Cooperative Shipping Associations

The origin of the cooperative shipping association plan can be traced to the Danish system of marketing eggs, which operated as early as 1895. The first record of its use in the United States was in 1913 under the name of the Community Egg Circle. The rapid increase in the popularity of this movement resulted in the establishment of egg circles at many points in the midwestern and southwestern parts of the country, where they met with varying degrees of success, but for the most part were comparatively short lived. Their lack of permanency may be attributed in part to their comparatively informal method of organization that made it difficult to control both quality and volume in a competitive market where buyers were not in position to find enough customers willing consistently to pay the premiums needed to encourage producers to follow the egg circle plan.

TABLE 1.—*Growth of egg and poultry auction associations, 1930-37*

Year	Associations operating	Number of active members	Volume handled	
			Cases of eggs	Crates of poultry
1930	2	350	13,510	....
1931	4	751	57,236	8,336
1932	11	1,951	137,098	21,198
1933	18	4,516	303,105	49,610
1934	21	7,139	447,859	66,112
1935	21	8,595	554,972	99,066
1936	22	10,538	740,814	138,649
1937	22	13,068	991,414	172,314

The functions of the cooperative shipping association in its present form are primarily those of a bargaining and administrative nature concerned with sales and supervision of the product of their producer members. The association itself serves only as a contact agency, leaving such details as the grading, shipping, and financial transactions to the individual producer, who deals directly with the buyer on the basis of an annual agreement made by the association.

Other cooperative associations marketing eggs

The marketing associations previously described confine their efforts mainly to the handling of poultry products. There are a great many cooperatives, however, which market eggs, and in some cases poultry, in conjunction with other agricultural products. These are usually located in areas where diversified farming is followed and where the production of poultry and eggs is generally confined to small-scale operations. Cooperatives of this nature frequently find their major problem to be one of securing a profitable outlet for all of the products handled, their principal advantage being the gain from added volume of other enterprises which reduces operating costs.

THE GROWTH OF COOPERATIVE EGG MARKETING ASSOCIATIONS

During the early period of development the growth of the cooperative egg marketing movement was slow and uncertain until 1917, when the first of the present day large-scale organizations was formed. From this time the number of organizations and the volume of business have increased until today eggs are marketed through more than 500 producer owned and operated cooperatives which have in recent years increased their volume to more than fifty million dollars worth of eggs annually.

SUMMARY

Most of the present egg marketing cooperatives have been developed within the past 20 years, before which numerous failures followed many cooperative egg marketing ventures. It has been found that cooperatives of different types are needed to fill the requirements of production areas located at varying distances from the market. To meet this need, four general types of marketing cooperative association have been developed, each of which works quite satisfactorily when located in an area suited to it. At present more than 500 cooperative associations are engaged in marketing eggs valued at more than $50,000,000 annually. The future of the cooperative egg marketing association depends largely upon its ability to furnish economically, over a long period, the essential services needed to place the producer's product in profitable market channels.

[2] By SCANLAN, J. J. and R. W. LENNARTSON, in News for Farmer Cooperatives, 1938, 6:13-14. Farm Credit Administration.

SERVICES TO POULTRY PRODUCERS' MARKETING ASSOCIATIONS BY THE FARM CREDIT ADMINISTRATION

By T. G. Stitts, *Chief, Cooperative Research and Service Division, Farm Credit Administration, Washington, D. C., U. S. A.*

Producers of farm products in the United States have been joining together for many years to perform certain business functions, especially marketing and purchasing, through cooperative associations owned and controlled by member-producers. As a part of their general farm policies, both State and National governments have sanctioned these organizations, and in many cases in recent years have adopted action programs designed to render services to them and to encourage their development along sound lines. Much of this work on the part of the Federal Government has been centered in the Farm Credit Administration since the agency was organized in 1933. This paper describes the services rendered by the Farm Credit Administration to farmers' cooperative associations, and indicates specifically how these have been related to cooperatives in the poultry industry.

With developments coming rather rapidly in the past two decades when the economic problems of farmers have been especially acute, agricultural cooperatives are significant in the marketing of practically all farm products, in the purchase of many farm supplies, and in several other farm services. The most recent estimates show for 1937–38 approximately 10,900 active marketing and purchasing organizations, with 3,400,000 farmer-members, and a volume of business of $2,400,000,000. In addition there are close to 2,000 farm mutual insurance companies, over 2,400 mutual irrigation companies, and many other cooperative organizations through which farmers obtain such services as telephone and electricity. The distribution of the cooperatives throughout the United States is shown in figure 1. The most recent development is the vast cooperative credit structure enabling farmers to obtain production and mortgage credit through their own local organizations.

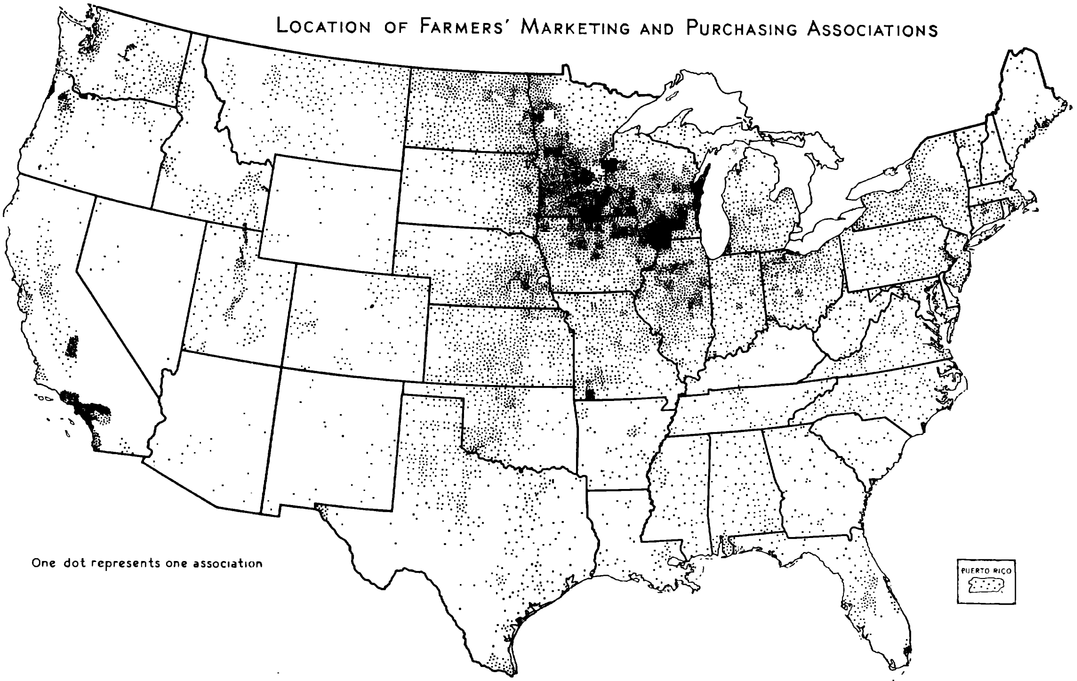


FIGURE 1.—There are approximately 11,000 cooperative marketing and purchasing associations serving 3,400,000 farmers in the United States. While associations are found in each of the States of the Union, there is the greatest concentration of associations in the Central West.

POULTRY PRODUCERS' COOPERATIVES

Poultry products are marketed for farmers by approximately 700 associations, located in all parts of the country. Based on the main commodities handled, only about 194 of these are classed as poultry products cooperatives. This relatively small group, however, does an annual business of approximately $91,000,000 for over 106,000 farmers. Significant volumes of eggs and poultry are also marketed through other types of associations, such as those selling butter and other dairy products, and much of the business of cooperative purchasing associations, especially in the Northeast and East and on the West Coast, is represented by poultry feed and other supplies for poultry farmers.

It is evident from these figures that although cooperatives serve many poultry farmers, these organizations handle only a small proportion of the total marketings of poultry products in the United States—probably less than 10 percent. This is low as compared with many other farm products, but the difference can probably be traced to peculiar conditions both in the production and in the marketing of poultry products, such as small units, noncommercial flocks, local markets, and other conditions, which make the need for cooperatives and the opportunity for them to operate efficiently and render a real service, less clear than in many other fields.

In a number of sections of the country, especially the West Coast, poultry cooperatives do handle a large share of the commercial production of eggs and poultry. State-wide organizations in Washington and Utah each handle over 60 percent of the eggs marketed by farmers in those States. Other associations in Oregon and California also operate on a large-scale basis, with 6 organizations in the four States having a total volume of business in 1937-38 of approximately $55,000,000. Five of these large organizations have joined together in forming a sales agency with headquarters in New York City to handle their eastern sales. Developments have been along somewhat different lines and on a smaller scale in other sections. Joint marketing of poultry and dairy products has been most common in the Middle West, with a large volume of eggs and poultry being handled by 3 or 4 organizations in particular whose principal business is in dairy products. In the East and Northeast there are a number of local poultry associations, an increasing number of egg auctions have recently been developed, and poultry products are handled by several of the cooperative purchasing organizations.

LEGISLATION FOR COOPERATIVE ORGANIZATIONS

These cooperative business organizations among producers of poultry and other farm products have contributed greatly to the economic and social welfare of farmers in the United States. There are manifestations of policy on the part of State and National legislative bodies dating back more than 20 years which recognize the benefits to farmers from cooperative organizations, and which also seek to encourage their development. The National Congress enacted legislation to clarify the legal status of farmers' cooperatives in 1914 and in 1922, providing specific exemptions from the anti-trust laws. Certain exemptions are also granted them with reference to Federal income taxes. Legislation in 1923, 1929, and more especially in 1933 provided specialized credit for these organizations; and acts passed in 1926 and 1929 were designed to assist and encourage cooperatives through a program of research, service, and educational work carried on by governmental agencies. It is a definite part of the national policy, therefore, to encourage agricultural cooperation.

Consolidated in the Farm Credit Administration now are the programs growing out of (1) the act in 1923 creating the Federal Intermediate Credit Banks, (2) the act in 1926 providing for research and service work relating to agricultural cooperatives (3) the Agricultural Marketing Act in 1929 setting up the Federal Farm Board and the revolving fund and (4) the act in 1933 creating the Banks for Cooperatives and amending and coordinating the other programs. Under this organizational set-up, the work is divided between the extension and supervision of credit to cooperative organizations of farmers, and a program of research and service work conducted on a national basis and designed to be of direct assistance to the associations themselves and to the movement.

THE BANKS FOR COOPERATIVES

The credit structure includes 13 banks—the Central Bank for Cooperatives in Washington, D. C., and a district bank in each of the 12 Farm Credit Administration districts. These banks have taken over the loaning functions of the revolving fund under the Farm Board, and the commodity loans formerly made to cooperatives by the Federal Intermediate Credit banks. The latter still offer a loan service to cooperatives as well as a discount service to the Banks for Cooperatives. Being located throughout the country, as shown in figure 2 the Banks for Cooperatives offer direct service to associations in every section in the way of loans for operating purposes, facility loans, and commodity loans. Agricultural cooperatives which meet the eligibility requirements may receive operating loans at 3 percent interest for whatever length of time good business practice requires. Facility loans are made for periods not exceeding 10 years, usually at 4 percent interest. Commodity loans are usually for 3- to 9-month periods at 2 percent interest.

Between May 1, 1933 and September 30, 1938, nearly 6,000 loans to agricultural cooperatives were made by the Farm Credit Administration in an amount totaling over $580,000,000. On November 30, 1938, 1,662 cooperatives had loans outstanding with the 13 Banks for Cooperatives, totaling over $86,000,000. These figures include loans of all three types, made to cooperatives in all parts of the country, and to cooperatives in marketing and purchasing, as well as farm services. Loans were outstanding to 29 poultry associations for a total of slightly less than

$2,000,000. These Banks for Cooperatives are designed as permanent credit institutions, loans are made on a sound business basis at uniform rates throughout the country, and losses have been so exceptionally low as to be almost non-existent. The credit is of a specialized type designed to meet the particular financial needs of farmers' organizations.

RESEARCH AND SERVICE PROGRAMS

The research and service work dealing with associations of producers of agricultural products, has been carried on by the Federal Government since 1926. The functions and purpose of the work is to render service to all farmers' cooperatives, including both borrowers and non-borrowers, and those engaged in marketing, purchasing, credit, insurance, and other service activities. Studies of cooperatives and service to cooperatives are stressed in the program which has been developed, with both types of activities conducted on a national basis and supplementing the work of State and local agencies along these lines. This cooperative research and service staff is the only agency—governmental or otherwise—designed to study and serve agricultural cooperatives on a national basis, and to meet the needs of these organizations, and the movement as a whole, for assistance of this particular type.

The program undertaken along these lines by the Farm Credit Administration may be said to have a threefold purpose. In the first place, it must determine the specific type of service and information such an agency as this can and should attempt to make available to agricultural cooperatives and to those working with cooperatives. Secondly, it is necessary to plan and conduct research studies and other activities to provide this information. Finally, the information gathered must be analyzed and made available in such a way as to render it most useful. Although the plan of work and the staff members have been divided more or less between research work on the one hand and service work on the other, the entire program is integrated along the three lines indicated above.

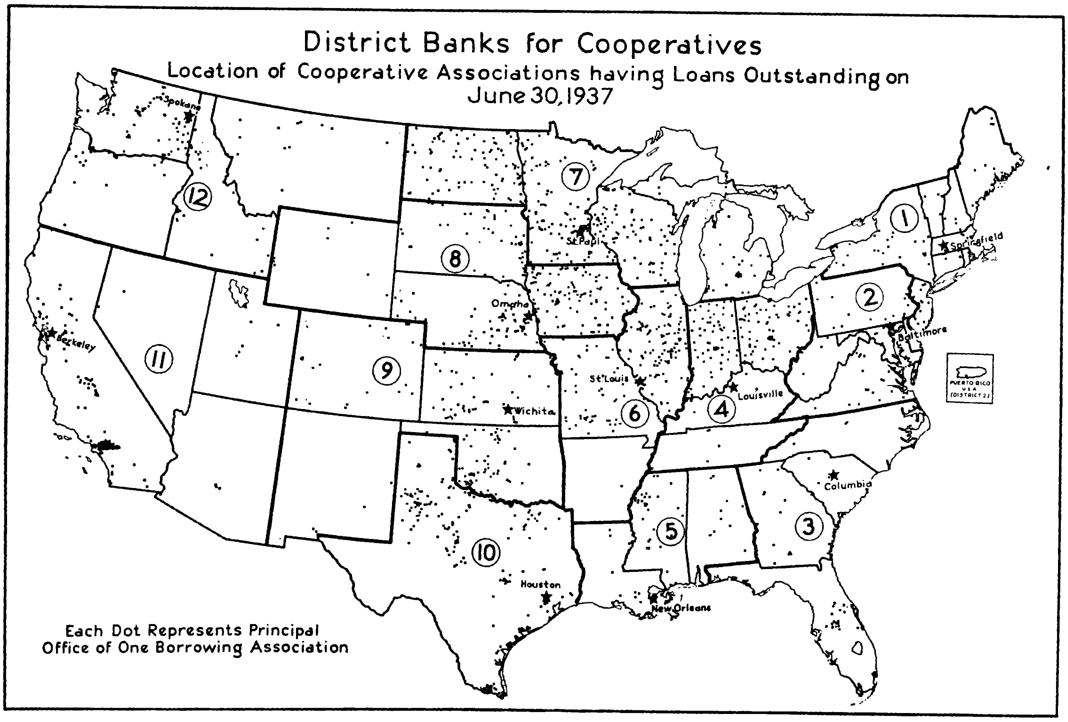


FIGURE 2.—There are twelve districts of the Farm Credit Administration. In each of these districts is a Bank for Cooperatives for service to cooperative associations. The Central Bank for Cooperatives has headquarters at Washington, D. C.

Research studies which have been made, and the results made available, have covered many phases of agricultural cooperative activity. There has been a continuous project, and several special studies, aimed at the collection and analysis of statistical and historical data on all agricultural cooperatives. Contacts have been established in this connection with more than 25,000 associations, many of them now inactive, and the file of information built up will be of increasing value in the future in tracing the early history and the progress of the movement.

Analytical studies of the general organizational structure and operating methods and problems of groups of associations in a particular field, business analyses of representative and successful cooperatives, and special studies of particular current problems, are included in the research work being undertaken. These studies cover a wide variety of subjects, such as legal, corporate, and financial structures; pooling practices and membership and management policies; transportation, processing and storage; costs, and price policies; and problems relating to competition, advertising, and general merchandising policies. Studies of this type form the basis for much of the direct service to cooperatives in the way of advice or special assistance, and they enable the Farm Credit Administration to serve as a clearing house for information on the principles and practices of cooperation among farmers. The essential fact is, of course, that practically all such studies grow out of requests from associations for a study of a special kind related directly to practical problems which they have to meet.

The research work is also designed to reveal current developments along economic, social, and legal lines which affect cooperatives, and to assist these organizations in making whatever adjustments may be necessary. Major shifts in operating policies are often called for by changes in economic conditions, in marketing and processing techniques, and in various phases of the national social structure. Studies of such changes, and their interpretation with reference to the cooperatives, need to be made from a regional or national point of view in many instances, and in all cases need to be conducted on a very practical basis.

Service work by the Farm Credit Administration for agricultural cooperatives is handled by a small staff of specialists who have a broad working knowledge of cooperative principles and their application, and also in many cases experience in the practice of cooperative business operations. This type of work and the research program supplement each other, with many of the projects calling for a research study followed by direct service work to insure full and proper use of the results. The service activities of the Farm Credit Administration are intended to supplement and coordinate the work being done along this line by State colleges and other agencies. In this way duplication is avoided, a large number of assocations are reached, and both the national and the local points of view are brought to bear on many problems.

Staff members engaged primarily in service activities do a great deal of work with the large regional and national marketing and purchasing organizations. They are called upon to render direct and immediate advisory service to active associations on a wide variety of special problems, and to advise with groups of producers interested in organizing new associations, or in reorganizing their old ones. Their work covers all phases of cooperative activity, and developments affecting prices and marketing conditions generally for farm products, both by cooperatives and by private agencies. This type of work and the frequent contacts it provides with industry, with State and local agencies in the same type of work, and with the cooperatives themselves, helps to keep the entire research and service program properly focused to render the most effective assistance to agricultural cooperatives.

Any number of illustrations might be used to indicate more clearly the nature of the research and service program undertaken by the Farm Credit Administration and the way in which it is pointed toward serving poultry associations and other farmers' cooperatives. In each of the fields of livestock, fruits and vegetables, and eggs and poultry marketing, for example, research studies are nearing completion on the auction method of selling, which has recently developed so much. In the Northeastern States, 25 cooperative egg and poultry auctions have been formed since 1930. The study of these associations by the Farm Credit Administration was undertaken in order to obtain information on their development, organizational structure, and operating methods, and to measure their effect upon prices and other marketing conditions, factors affecting their success, and general conditions under which the auction method might be most suitable. Member and nonmember producers, auction buyers, truckers, and many other individuals and agencies were contacted in obtaining data and information. The results of the study will be published, and should be especially useful to the particular associations studied and to other groups of producers interested in this method of selling eggs and poultry.

The analysis of statistical and accounting practices of the six large egg and poultry associations in the Far West, the help in organizing a new regional turkey marketing association, and the general work with the other large turkey cooperatives, are illustrative of the service projects undertaken by the research and service staff. The first project mentioned embraces the 5 large poultry and egg associations in Washington, Oregon, and California which are members of the joint eastern sales agency, and also the Statewide association in Utah. Assistance in appraising, revising, and coordinating their statistical and accounting practices was requested by these associations, and the work was undertaken late in 1938. The essential purpose is to work out from a practical point of view, and to help the associations put into operation, systems of accounting and methods of statistical procedure which will lead to greater efficiency and lower costs, and will facilitate comparisons among the associations on such matters as unit costs and financial condition. Service of this type and that which grows out of research projects should be valuable in helping agricultural cooperatives to develop into sound and efficiently operated organizations. Together with the credit facilities designed for their special needs, it represents a comprehensive program on the part of the Farm Credit Administration to help the cooperatives to help the farmers.

SUMMARY

Recognizing their actual and potential contribution to the economic welfare of producers of farm products in the United States, the Federal Government has been committed for a number of years to a policy encouraging the development of and rendering services to agricultural cooperatives. The Farm Credit Administration since its organization in 1933 has been charged with administering many of the programs provided by legislation under this broad policy, including (a) the extension of specialized credit to qualified farmers' cooperatives and (b) a comprehensive program of research and service work relating directly to these organizations and their problems, and designed to encourage and guide their development.

These services are available to all agricultural cooperatives, those engaged in marketing, purchasing, insurance, irrigation, and other farm services. More than 6,000 loans have been made by the Farm Credit Administration to qualified organizations since May, 1933, including commodity, operating, and facility loans. On November 30, 1938 more than 1,600 cooperatives were active borrowers from the Central and the District Banks for Cooperatives, among them 29 poultry and egg associations. Research and service work, which is now a part of the Farm Credit Administration's service to cooperatives, has been carried on since 1926, when provision was made for it in a special act of Congress. Its function is to collect, analyze, and disseminate information, and to give direct assistance and advice with reference to the agricultural cooperative movement as a whole, to groups of associations, to individual organizations, and to groups of farmers interested in forming a cooperative. For poultry cooperatives as well as for those in other fields, the work covers a broad field, including such matters as general trends and developments and specific problems of operating methods and practices. A research study of cooperative egg and poultry auctions in the Northeast and a service project designed to improve the accounting and statistical practices of 6 large poultry and egg associations in the Far West are recent illustrations of the way this program has served poultry producers' cooperative associations.

RETAILING GOVERNMENT GRADED EGGS IN OHIO

By RAYMOND E. CRAY, *Poultry Extension Specialist, Ohio State University, Columbus, Ohio, U. S. A.*

The soundness of the principle of marketing eggs on a graded basis is generally recognized by all phases of the industry, but the application of the principle to actual marketing practices in the Middle West has met with many difficulties.

Failure of producers, distributors, and consumers alike to appreciate the perishability of eggs and to understand the factors affecting their perishability has been a serious handicap to the widespread adoption of the practice of buying and selling eggs on a graded basis. The quality of most perishable foods is revealed by their appearance, and proper discriminations can be made by the purchaser, but the eggshell conceals its contents, a fact which seriously complicates the marketing of eggs on a quality basis.

The results of consumers' attempts to purchase good eggs from regular retail food distributors in Ohio have been pitiful. The consumer can demand fresh eggs, but has no practical means of judging their quality before use. Purchases of so-called "fresh eggs" by the supervisor of Government egg grading made annually during the last four years from leading retail stores in several Ohio cities, have failed to show any relationship between the price paid for eggs and either the quality or the size of the eggs purchased.

Much progress has been made toward the solution of this problem by many of the eastern States through so-called "fresh egg legislation," which in effect prescribes the standards of quality that eggs must meet in order to be retailed as "fresh eggs," but in Ohio practically all eggs, regardless of their quality, are sold as "fresh eggs."

Most Midwest housewives are price conscious and the Midwest cities are consequently still predominantly low-price egg markets, but during the last few years it has been possible in Ohio to start well-planned and carefully executed programs of retailing quality eggs. Here in Cleveland the Fisher Brothers Grocery Company, a local chain of approximately 300 quality food stores, is demonstrating that the accepted philosophy of the egg trade that Midwest housewives will not pay a premium for good eggs is wrong, provided a retailing system is developed that will guarantee consumers good eggs when the premium is paid.

Despite previous efforts of this organization to handle good quality eggs, numerous complaints were received from customers each year during the hot summer and autumn months. Consequently, the Fisher organization was looking for the very plan that the Ohio Farm Bureau Cooperative Association offered[1] when they suggested supplying eggs packed in cartons, sealed with the Government certificate of quality, bearing the official approval of the United States Department of Agriculture. The plan offered a sound basis for judging consumer preferences and an opportunity to enhance the company's prestige as a distributor of quality products, by being the first organization in Cleveland to use such a merchandising plan.

The detailed program was developed, criticized, built and rebuilt, by the chief executives of this organization before any publicity or advertising was released. The fact that the chief executive worked out the program meant that it commanded constant attention. Attempts have been made by managers of the egg departments of other chain organizations in Ohio to develop quality egg programs, but because the program lacked the interest and support of the chief executives it failed to get the support of the store managers.

The thoroughness with which the details of this program of retailing Government graded eggs was developed and the precision with which it has been carried out, are doubtless factors fundamental to the success of any large-scale quality egg retail marketing program in the Midwest. The program involved a considerable amount of educational work. First, the store executives, who on the basis of their past experience were reluctant to believe that good eggs were obtainable from Ohio producers during the summer months, had to be convinced that a supply was obtainable. Second, the store managers, who previously had handled eggs as any other commodity, had to be impressed with the perishability of eggs. Third, consumers needed to be educated to the fact that eggs of guaranteed quality were available at the Fisher store in their neighborhood.

The supervisor of State-Federal egg grading in Ohio and the poultry extension specialists held meetings with the store executives, store supervisors, and store managers to explain what was involved in the production of quality eggs, how eggs must be handled by farmers, processors, and retailers, to preserve that quality and how the quality of the different grades is determined by the candling light.

The problem of educating the consumer was more complicated and was accomplished largely through developing the advertising campaign into a consumer educational program.

The advertising and sales promotional literature emphasized the cooperative responsibility of the four agencies involved in the program: The Ohio farmers who produced the eggs, the Ohio Farm Bureau Cooperative Association which collected the eggs at country points, the United States Government which made the final inspection and supervised the sealing of the cartons, and the chain organization store, which rushed the eggs to the consumer.

A competitive store used phrases like the following in its advertising to convince consumers of the quality of eggs they sold:

> None of the chickens that produced these eggs speak French, wear evening gowns, or drink Martinis, just the old-fashioned, home-loving kind that rise early, work hard, and go to bed with the chickens and they sleep in feather beds too. Just good eggs—breakfast, lunch or dinner—one crack and everyone smiles—that's really fresh.

Compare the actual information regarding the quality of eggs offered for sale in the above advertisement with a typical Fisher advertisement showing Uncle Sam holding a carton of White Gem Eggs and pointing to the certificate of quality with the following statement:

> Don't take OUR word for it—UNCLE SAM CERTIFIES THESE EGGS.
>
> As a matter of fact, we've told you our story in the headline above. Let us merely repeat the steps in the new egg deal by which Fishers have placed Government-certified Fresh White Gem eggs in every Green and Gold Food Store.
>
> First: White Gem eggs are laid on nearby Ohio farms, by hens bred and scientifically fed, according to formulas developed by the Ohio Farm Bureau Cooperative Association to produce eggs of quality.
>
> Second: The Ohio Farm Bureau Cooperative Association collects these eggs, candles and grades them, and rushes them to the Cleveland Terminal, largely during the night.
>
> Third: Inspectors licensed by the Federal Department of Agriculture as well as by the State Department, again grade these eggs, certify their quality, supervise their packing into cartons sealed with the dated certificate of quality.
>
> Fourth: Fisher's Speedee Special Delivery trucks rush them to every Green and Gold Food Store.

In addition to half page advertisements of this type in the Sunday newspapers over a period of several weeks the organization also used 68 billboards scattered over the city, to tell the story of the quality egg program. The stores used large display signs and special counter display signs emphasizing the Government "Certificate of Quality" used to seal the cartons of White Gem Eggs as a guarantee of satisfaction to the consumer. A display truck with float featuring the egg program, was run through every section of the city during the first few weeks and the trucks delivering foods to the Fisher Stores all carried signs telling about the quality egg program. Figure 1 shows some of the characteristics of this advertising.

The program also involved changing physical equipment and the development of proper methods of handling quality eggs by the retail organization itself. Eggs had previously been

[1] "The Egg Standardization and Grading Program in Ohio" by Ray C. Wiseman, page 331 in this volume.

delivered to the stores once or twice a week, with the other merchandise, but with the development of this program, three new trucks were used to deliver eggs and butter only. These trucks were insulated on the top, sides, and bottom with 4 inches of cork and a schedule was worked out to guarantee delivery to every store three times a week.

mistakes, but by either the Government inspector or by a member of the Farm Bureau Cooperative Association and twenty-two of the complaints were found legitimate.

The complaints which indicated laxness in the execution of some detail of the program were brought to the attention of the proper parties and the causes immediately rectified. This record of

FIGURE 1.—Typical newspaper advertisements used to promote sales of U. S. Extras quality eggs

The truck drivers are not salesmen and, therefore, have no tendency to overstock the stores; in fact, it is the driver's responsibility to limit the store manager to a 2-day supply of eggs. The store supervisors further guard against the egg stock accumulating by checking the dates on the certificate of quality sealing the cartons, and any carton that is 5 days old is broken open and the eggs placed in the lower grade sold by the stores. The eggs are kept in refrigerator show-cases in the stores and empty cartons are used in the counter displays. This practice has since been generally adopted during the summer months by the better retail organizations in Cleveland.

The guarantee of satisfaction to the consumer was further guarded by inserts placed in the cartons telling the consumer how carefully the eggs had been handled until the time she had purchased them and urging her to keep the eggs in the refrigerator until they were used.

Perhaps the greatest source of satisfaction to the Fisher organization in this program of retailing Government graded eggs has been the almost complete elimination of complaints from customers. Thirty-nine complaints were received from the first 4,000,000 dozen eggs sold in cartons sealed with the Certificate of Quality! These complaints were immediately investigated, not by a member of the chain organization, who would in the eyes of the consumer make excuses for their

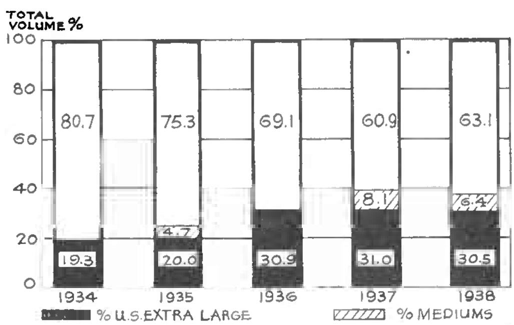


FIGURE 2.—Sales of the highest quality eggs have increased materially during the last 5 years.

complaints would compare favorably with even a nonperishable commodity and offers concrete evidence of the success of this type of quality egg merchandising program.

This chain organization has always sold two grades of eggs: one a fine quality high priced egg, the other a lower priced, ordinary quality egg. With the adoption of the program to guarantee the consumer fine quality eggs by virtue of sealing the cartons with the Government Certificate of Quality, the percentage of the total volume of eggs represented by the high quality grade has shown a material rise as indicated in figure 2.

During the last two years, a fine quality medium size egg has also been sold during the high-price season with a tendency to keep people using the fine quality eggs throughout the year although they shift from the large to the medium size during the high price season.

The Fisher organization is only one of several agencies in Ohio retailing Government graded eggs, but because they are located in Cleveland, where Congress visitors may personally study their program, and because of the very thorough manner in which the program was developed and executed, the writer felt justified in discussing it as an outstanding example of what is involved in the promotion of a successful program for the retail merchandising of Government graded eggs in Midwestern cities.

The publicity given to the sale of good eggs has resulted in the other large retail organizations in Cleveland selling better quality eggs, too. Other chain organizations usually sell eggs at a substantially higher price in Cleveland than in other Ohio cities even though they carry the same brand name, but examination has always shown that the eggs sold in Cleveland are better quality eggs.

The publicity given this program has no doubt helped to expand the demand for quality eggs in northeastern Ohio. As illustrations, the volume of the Wooster Auction eggs which are going to Ohio outlets has increased about 700 percent in the last 7 years, and during the first 6 months operation of the recently developed Versailles Egg Auction in western Ohio, approximately 55 percent of the eggs were sold in northeastern Ohio markets.

In reviewing the program of retailing Government graded eggs in Ohio, the following factors stand out as important considerations in the success of the program:

1. Little progress had been made in the retailing of fine quality eggs on a large scale in midwestern markets prior to the development of the Fisher program in Cleveland.
2. Purchases of so-called, "fresh eggs" in other Ohio markets during the fall months have failed to show any correlation between price and either the quality or the size of the eggs.
3. A complete and detailed merchandising program was developed by the executives of the Fisher organization and the cooperation of the store managers was consequently guaranteed.
4. Methods were developed for the delivery and handling of the eggs to guard their quality until they have reached the consumer.
5. The advertising program was built as a consumer educational program on quality eggs.
6. While complaints were few, each was thoroughly investigated and the cause remedied.
7. The volume of eggs sold by the organization was large enough to provide ample advertising funds without causing a burdensome overhead.
8. The quality egg merchandising program of the Fisher Stores led to improvement in the quality of eggs sold by competitors and created a larger market for quality eggs throughout northeastern Ohio, disproving the theory that Midwest consumers will not pay a premium for quality eggs.

SUMMARY

Methods in the retailing of Government graded eggs are discussed as they have been developed by a large retail chain organization in Cleveland. A complete and detailed merchandising program for Government graded eggs was developed by the executives of this organization and the active cooperation of the store managers was enlisted. Methods were developed for the delivery and handling of the eggs to guard their quality until they reached the consumer. The advertising program was carried out as a consumer educational program on quality eggs. While complaints were few, each was thoroughly investigated and the cause remedied. The volume of eggs sold by the organization was large enough to provide ample advertising funds without causing a burdensome overhead.

This merchandising program led to improvement of the quality of eggs sold by competitors and created a larger market for quality eggs throughout northeastern Ohio.

THE COMMERCIAL HATCHERY INDUSTRY IN THE UNITED STATES

By B. H. Bennett, *Agricultural Statistician, Bureau of Agricultural Economics, and* C. C. Warren, *Assistant Agricultural Economist, Agricultural Adjustment Administration, United States Department of Agriculture, Washington, D. C., U. S. A.*

Although the commercial hatchery industry is a development of the twentieth century, history records that the principle of artificial incubation of eggs was known to the ancients of Egypt and China. The methods then used were crude, measured by present standards, but they possessed certain essentials of efficiency and satisfaction as illustrated by the fact that in some sections of those countries the same procedure, with only minor modifications, is still being followed.

The methods of the ancient Egyptians and Chinese, however, were not suited to the conditions of the early poultry industry of Europe and later America with their scattered small units of production. With modern industrial advance during the past 200 years numerous attempts were made to develop more satisfactory and economical methods. In 1770 John Champion of England was successful in hatching eggs by heating a room with hot air which had been passed through a series of flues. Seven years later a French physician named Bonneman used circulating hot water to heat the hatching units.

BEGINNINGS IN THE UNITED STATES

The first record of an American incubator was in 1844 when an English patent was issued to cover the "Cantela Patent Incubator." It was not until 1870, however, that serious attention was devoted to the problem. In that year a patent was issued to Jacob Graves for an "Incubator and Artificial Mother," and he began advertising baby chicks for sale as early as 1873. His hatchery, located in Massachusetts, was the earliest known hatchery in the United States. The father of the present owner of one of the pioneer hatcheries in Petaluma, California, the late Christopher Nisson, began selling baby chicks in 1883. Another old hatchery in Petaluma, the Bourke and Salis Hatchery has been operated by fathers and sons continuously since 1888.

The first really successful American incubator, the Monarch, was introduced to the public in 1884. It was followed a year later by an individual brooder. This last was an especially important development, for without mass-methods of raising hatchery chicks, artificial incubation would be of limited value.

The first American incubators offered for sale were primarily adapted for home use or, if commercially operated, to local requirements only. The radius of chick sales was governed largely by the distance that could be covered by a horse and wagon in the course of a day. Recognizing that the full possibilities of commercial incubation could be realized only by widening the marketing or sales radius, an enterprising hatcheryman, Joseph D. Wilson, of Stockton, N. J., made the epochal attempt to ship chicks by express in 1892. The shipment from Stockton to Chicago, Illinois was fully successful. It immediately opened the way for enlarging the demand for hatchery chicks and offered a further incentive for the expansion of the industry on a commercial scale.

The next important event was the construction of the first mammoth incubator by Charles A. Cyphers, at Stroudsburg, Pennsylvania, in 1895. This incubator, in the form of a room, had a capacity of 20,000 duck eggs. Although partially successful, there was no immediate demand for an incubator of that size. The shipment of day-old chicks in quantity was still a matter for future development.

Further attempts were made by Cyphers, Hall, and others to develop practical mammoth incubators during the early years of the Twentieth Century. These efforts resulted in the invention of many ingenious and successful features. But it was not until 1918 that patents were issued to Dr. S. B. Smith that practically revolutionized the construction of large-size incubators, and gave additional stimulus to the hatchery industry which was then emerging from its infancy stage.

PERIOD OF RAPID EXPANSION

Following 1918 contributions in the improvement of mammoth incubators, as well as of the smaller sizes, were made by many others. Particularly important was the invention of the electrically heated and electrically controlled mammoth incubator by Ira M. Petersime, in 1923.

Another event of fundamental and far-reaching significance was the acceptance by the United States Post Office in 1918 of shipments of baby chicks by parcel post. This event had an immeasurable influence in stimulating the growth of the hatchery industry, for shipment by Parcel Post was not only speedy, safe, and economical, but it also opened up a tremendous marketing area not served by other transportation facilities.

TABLE 1.—*Relative importance of 8 different capacity classes for 11,405 hatcheries in the United States, July 1, 1934*

Capacity class	Hatcheries	Percent of total	Order of importance	Capacity	Percent of total	Order of importance
	Number	*Percent*		*1,000 eggs*	*Percent*	
1. Under 10,000 eggs	4,934	43.3	1	19,110	6.9	7
2. 10,000 to 24,999	3,315	29.1	2	50,774	18.4	1
3. 25,000 to 39,999	1,274	11.2	3	39,370	14.2	4
4. 40,000 to 59,999	895	7.8	4	42,481	15.4	3
5. 60,000 to 99,999	576	5.0	5	44,744	16.2	2
6. 100,000 to 199,999	294	2.6	6	38,790	14.0	5
7. 200,000 to 499,999	102	.9	7	28,946	10.5	6
8. 500,000 and over	15	.1	8	12,072	4.4	8
Total	11,405	100.0	.....	276,287	100.0	.....

Throughout the period of technical improvement in incubating methods the production of hatchery chicks experienced a slow but steady expansion. No definite records are available on the number of individuals or companies engaged in hatching baby chicks for sale during these early years, but most authorities place the number at less than 100 up to 1910. Even when the International Baby Chick Association was organized in 1916, only 200 hatcheries were known to be in operation.

1934 is the first year for which there is an authentic record of the number of hatcheries in the United States. A survey of the industry made by the Agricultural Adjustment Administration found 11,405 plants. These plants had a total capacity of 276,287,000 eggs, and in 1934 had an estimated production of 453,367,000 chicks. Table 1 shows the number of hatcheries operating in 1934 and their capacities as classified into eight different size groups. It will be noted that the group having the greatest total capacity was made up of hatcheries with individual capacities of

10,000 to 25,000 eggs. Plants of this size normally utilize the full time of one man to the greatest degree of labor efficiency.

It is regrettable that no records are available that would show the year-by-year growth of the hatchery industry. In another survey of this industry being made by the Agricultural Adjustment Administration data on its growth are being obtained. An analysis of a portion of the returns already received is presented in figure 1. This chart shows the number of plants that began operations in the years indicated at the bottom of the chart. It should be noted that the great expansion began in 1919 and continued until 1929 before showing any evidence of slowing down.

The expansion indicated by this chart does not mean a corresponding increase in the production of poultry and eggs. The production of poultry and eggs did expand, but the hatchery industry expanded even more rapidly as the economies of purchasing hatchery chicks of definite qualities became more widely recognized. The increasing

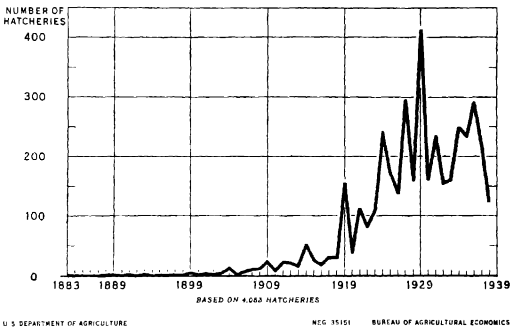


FIGURE 1.—Number of hatcheries established yearly, 1883–1938. The first commercial hatchery began operating in 1883. There are now about 12,000. Practically all of this increase has occurred since 1919.

importance of commercial hatching is illustrated by two surveys made by the United States Crop Reporting Board of the Department of Agriculture in 1928 and 1934. The 1928 survey revealed that approximately one-third of all chicks then hatched were produced in commercial and breeder hatcheries, whereas in 1934 this proportion had increased to almost one-half. Today the proportion is probably even larger.

Another significant trend in recent years is that hatcheries are tending to operate for a longer period of time during the year than was formerly the practice. It is doubtful whether 15 years ago a single hatchery in the United States operated for more than 5 or 6 months during the year.

Today the situation is markedly different. Results of a preliminary analysis of over 4,000 returns from the survey of the hatchery industry now being made appear in figure 2. This figure shows the percentage of the 4000 hatcheries operating each month from August 1, 1937 through July 31, 1938. Of this number, 3.5 percent were in operation every month of the year, 9.2 percent operated 9 months or more, and 35.0 percent, 6 months or more. In analyzing these data, it is found that the plants which operated in every month are concentrated for the most part in the areas where there are many large egg-producing flocks, or where the production of broilers is particularly important.

The era of technical improvements in hatchery methods is not yet over, but so much has been accomplished already in that direction that the industry now finds time to devote to other types of development.

For example, for many years it has been known that the sex of baby chicks could be determined by cross-breeding, but no important commercial use was made of this knowledge. But, a few years ago, hatcheries on the Pacific Coast began using the Japanese visual method of sexing. By 1939, this practice had become very important

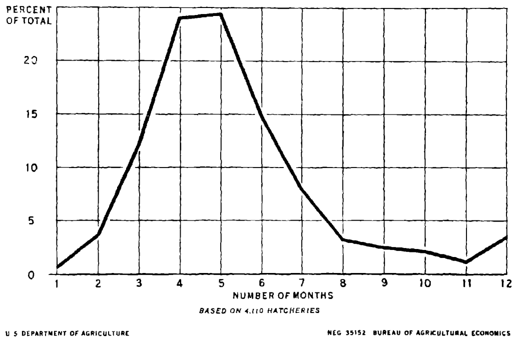


FIGURE 2.—Percentage of total hatcheries operating each month, August, 1937–July 31, 1938. About one-half of all hatcheries operate four or five months each year. Of great importance is the trend for hatcheries to operate for longer periods of time. A total of 35.0 percent operated 6 months or more.

and had spread throughout the entire country. Hatcheries find that the demand for sex-separated chicks comes predominantly from those areas where egg production is highly specialized. As poultrymen on the Pacific Coast have specialized particularly in commercial egg production, sexing in that area is more general than in any other part of the country.

TURKEY HATCHING MADE PRACTICAL

Until only a few years ago, it was thought impossible to hatch turkey eggs economically in incubators. But because of recent technical improvements in incubator operations and equipment, turkey poults are now hatched in commercial hatcheries in great volume. Some incubator manufacturers now produce machines designed especially for incubating turkey eggs.

The ability to obtain turkey poults in relatively large numbers without the need for maintaining expensive breeding flocks has changed turkey raising almost overnight from a side-line farm enterprise to a large-scale mass-production industry. Flocks of 15,000 to 20,000 turkeys are not at all uncommon today, whereas only a few years ago a flock of 1,000 birds was considered large. No data are available on what proportion of the total number of the turkeys raised is commercially hatched, but it is known to be increasing rapidly.

It is difficult to measure the influence of artificial incubation on the egg and poultry industry in the United States. It can be said, however, that without the hatchery industry it would have been impossible for the commercial production of eggs and poultry to have reached its present size or degree of efficiency. It unquestionably ranks in importance along with such outstanding contributions as the discovery of sanitation in controlling certain poultry diseases and the role of nutrition and breeding in the production of eggs and poultry.

HATCHERIES AS MEANS FOR IMPROVEMENT OF STOCK

Although the direct effects of the hatchery industry have been largely economic in nature, it has become an increasingly important channel for the distribution of improved strains and breeds of poultry developed by breeder hatcheries. A breeder hatchery is defined as one which produces chicks, ducklings, or poults primarily from its own flocks and usually follows a definite breeding program in the production of particular breeds or strains. This type of a hatchery is the direct result of the growth of the commercial egg and poultry production industry and the demand of commercial egg and poultry producers for better bred chicks.

Commercial hatcheries are more and more availing themselves of the services of these specialized breeder hatcheries. Stock purchased from breeders is used to improve the quality of the flocks which supply the bulk of the hatching eggs used by plants that do not find it practicable to follow a specialized breeding program of their own. In this way the work of intelligent breeders can, within a reasonably short time, be converted into practical results of increased productivity of eggs and improved quality of poultry meat.

The increase in the industrialization of the poultry industry has caused a sharp rise in poultry mortality in both young and adult stock, due to various diseases as well as to an apparent decline in livability. This mortality has reached such proportions as to cause a serious threat to the poultry industry in some sections of the country.

To bring about a reduction in losses due to controllable diseases, as well as to provide official recognition to poultry breeders for their breeding records, the National Poultry Improvement Plan was initiated in 1935. This Plan, administered by official State agencies in cooperation with the Department of Agriculture, has been instrumental in focusing the attention of many hatcheries on the need to improve the quality and viability of their chicks, as well as to increase egg-laying ability. A description of the methods and objectives of the Plan is being presented to this Congress in two papers prepared by Mr. Paul Zumbro and Mr. Berley Winton, who are both closely connected with its operations.

NEWS SERVICES FOR HATCHERYMEN

The United States Department of Agriculture has been helpful in the economic as well as the purely technical phases of hatchery operations. Since 1931 it has issued a monthly hatchery chick production report throughout the season of major production. This report is compiled from data obtained from a sample group of widely distributed hatcheries, and has served as a measure of the current changes in incubator capacity, the number of eggs set, and the number of chicks hatched. Recently it has been expanded to include changes in the number of turkey eggs set and poults hatched, and the number of chicks sexed. These data, used in connection with other information on the poultry industry compiled by the Department, enable hatcheries to keep informed on current conditions and trends.

The production of eggs and poultry ranks high in importance among the agricultural industries of the United States. Approximately 86 percent of all farms reported poultry on hand in the agricultural census of 1935. During the early years of the hatchery industry only a few of its leaders could visualize the position it would one day occupy in relation to, and the influence it would ultimately yield, in shaping the developments of the egg and poultry industry. Today its leaders have accepted their share of the responsibility for solving some of the major poultry industry problems. As this responsibility becomes more widely accepted by its members, the hatchery industry will assume an even more important and useful part in directing the policies and developments of the egg and poultry industry of tomorrow.

SUMMARY

The principles of incubating eggs artificially were understood by the early Egyptians and Chinese, but no serious efforts were made in America to apply these principles to hatching chicks until toward the close of the 19th century. The first known record of hatchery chicks advertised for sale was in 1873, and the first successful small unit incubator appeared in 1884.

The first mammoth incubator was built in 1895. Subsequent attempts to improve the construction and operation of large size incubators culminated in 1918 when patents were issued which practically revolutionized artificial hatching procedure. Another important event of 1918 was the approval of the United States Post Office of the shipment of baby chicks by parcel post. In 1923 the first electrically heated and electrically controlled incubator was invented.

Less than 100 hatcheries were known to be in operation prior to 1910, and only 200 in 1916. The

years of 1920 to 1930, however, were years of rapid expansion, and in 1934 over 11,000 plants were reported to be in operation. Hatchery chick production in 1934 was estimated at around 453,000,000 chicks.

The first hatcheries operated for only a few months during the year. Preliminary analysis of returns from a survey of the hatchery industry now being made by the Department of Agriculture indicates that approximately 3.5 percent now operate through the entire year, 9.2 percent, 9 months or more, and 35 percent, 6 months or more.

Recent important developments include hatchery sexing of baby chicks according to the Japanese method of visual examination, the incubating of turkey eggs in increasing quantities, and the improvement of the quality of hatchery chicks through participation in the State and Federal breed-improvement and disease-free programs under the auspices of the National Poultry Improvement Plan.

ECONOMIC ASPECTS OF THE FROZEN-EGG INDUSTRY IN THE UNITED STATES

By JAMES H. RADABAUGH, *Associate Agricultural Economist, Poultry Section, Agricultural Adjustment Administration, United States Department of Agriculture, Washington, D. C., U. S. A.*

The breaking and freezing of eggs had its beginning as an industry early in this century. At that time and until comparatively recent years, eggs were broken and frozen in order to prevent loss of poor quality eggs which could not endure the rigors of normal marketing. In a publication dealing with the cold storage of eggs and poultry, Heitz[1] makes the following statement:

> In the spring of the year, during the heavy egg-packing season, there are always many undersized, dirty, and cracked eggs on the market. The shipping of these eggs to terminal markets would result in heavy financial loss to the packers. To take care of this situation many egg packers break the eggs from the shell and freeze them, or ship them to nearby egg-breaking establishments, where they are broken and packed. The frozen-egg industry has grown to enormous size in the last several years, and the demand for frozen eggs has been so great that dealers now find it profitable to break high-grade eggs from current receipts for their frozen supply.

This in brief is the history of the industry.

CHANGING NATURE OF THE SUPPLY

While the industry had its beginning as a means of handling what might be termed a byproduct of the egg-packing business, it has now changed to one the growth of which has been due to constantly increasing demand for eggs in a convenient form.

While the industry was undergoing a fairly gradual growth after 1917, a relatively sudden change in emphasis occurred in 1927, as indicated in figure 1. Prior to 1927 eggs were broken from the shell in all the months of the year and a large percentage of frozen-egg holdings was accumulated during June, July, and August, when a considerable proportion of shell eggs suffers from deterioration due to hot weather. An important part of frozen-egg holdings since 1927 has been produced during March, April, and May, when the best eggs are available. Prior to 1927, storage holdings on June 1 were not significantly higher than on February 1, indicating that the movement into storage did not become heavy until June 1 and was unimportant during March, April, and May.

GROWTH OF THE INDUSTRY

The extent of the increase in egg-breaking operations is apparent from the case-equivalent[2] storage holdings of frozen eggs as of August 1 from 1916 through 1938,[3] as shown in table 1. Frozen-egg holdings increased from 166,000 cases in 1916 to 4,768,000 cases in 1937. The solid line in figure 1 shows the growth of this industry as measured by the August 1 cold-storage holdings since 1917. Although the actual holdings of frozen eggs were less in 1938 than in 1937, they formed a larger percentage of the total holdings of eggs in storage on August 1. The column in table 1 showing the percentage frozen eggs are of total August 1 storage holdings indicates that in 1916 frozen-egg holdings were about 3 percent of total August 1 holdings and have risen to a high in 1938 of about 38 percent of the total.

Estimates of production begin with 1921 and show an increase from 46,000,000 pounds in 1921 to 225,000,000 pounds in 1937, the peak year, when about 6,400,000 cases of eggs were broken and frozen (table 2). The estimates for 1921-36 were made by the United States Tariff Commission, based on original entry of frozen eggs into cold storage. The estimates for 1937 were made by the Poultry Section of the Agricultural Adjustment Administration.

[1] HEITZ, THOMAS W. The Cold Storage of Eggs and Poultry. U. S. Department of Agriculture Circular No. 73 (Revised May, 1938).

[2] In the compilation of these figures, a conversion factor of 35 pounds of frozen-egg products was used as the equivalent of one 30-dozen case of shell eggs.

[3] The Bureau of Agricultural Economics monthly storage-holdings series begins as of May 1, 1916.

Future trends in volume are unlikely to continue their recent rapid advance, since it is reasonable to assume that at some point frozen eggs will have reached the limit of substitution for all the eggs they might logically replace. Some individuals anticipate the use of frozen eggs in smaller packages for home consumption, but a development of this kind in the immediate future appears unlikely.

REASONS FOR GROWTH

The industry's phenomenal growth may be attributed to improvements in methods of breaking, freezing, transporting, and merchandising frozen eggs; use of higher quality eggs; increased observance of sanitary measures; better refrigeration; and the recent introduction of the 10-pound container. More recently, however, the increase has been due to a greater demand brought on by changes in the eating habits of the urban population. Consumers are displaying an increasing desire for prepared foods. Home-baking has been supplanted by use of the products of large commercial bakeries that find frozen eggs in large quantities more practical than shell eggs. The commercial manufacturers of salad dressing, noodles, candies, and confectioneries of all kinds also have become large users of these products. The use of frozen eggs is more convenient for these manufacturers than that of shell eggs for several reasons: Frozen eggs can be purchased in the form needed, such as frozen whole egg, plain albumen, plain yolk, and yolk emulsions in any quantities desired; the manufacturer is relieved of the trouble and expense of providing breaking facilities; and no loss is suffered from inedible eggs. Large restaurants and hotels also have become important outlets for this type of product.

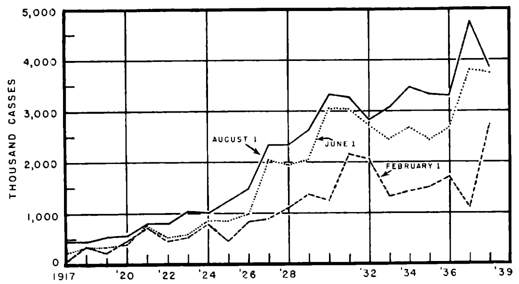


FIGURE 1.—U. S. cold storage stocks of frozen eggs on February 1, June 1, and August 1, 1917–38. Since 1927 the into-storage movement of frozen eggs has been practically completed by June 1, indicating the use of better quality eggs for breaking purposes.

COMPARISON OF COSTS—FROZEN AND SHELL EGGS

Estimates of the cost of breaking and holding frozen eggs as compared with the cost of handling and storing shell eggs are shown in table 3. It appears to be slightly more expensive to process, store, and hold frozen eggs than eggs in the shell. The total cost for storing shell eggs is estimated at about 4.4 cents and for frozen whole eggs, about 4.91 cents per dozen. If, however, freight on case eggs from some interior point such as Kansas City to New York is added, the cost of frozen eggs is approximately one fourth of a cent less per dozen than that of shell eggs. The chief advantage which frozen eggs may have as compared with shell eggs, however, should be limited to the advantages obtained after delivery.

TABLE 1.—*Cold-storage holdings of eggs in the United States on August 1, 1916-38*

Year	Holdings: Frozen eggs	Holdings: Shell and frozen eggs	Percentage frozen eggs of total holdings	Year	Holdings: Frozen eggs	Holdings: Shell and frozen eggs	Percentage frozen eggs of total holdings
	1,000 cases	*1,000 cases*	*Percent*		*1,000 cases*	*1,000 cases*	*Percent*
1916	166	6,226	2.7	1928	2,333	12,829	18.2
1917	440	7,335	6.0	1929	2,614	11,576	22.6
1918	435	7,003	6.2	1930	3,322	14,520	22.9
1919	544	8,394	6.5	1931	3,277	12,781	25.6
1920	573	7,445	7.7	1932	2,832	9,263	30.6
1921	799	8,404	9.5	1933	3,076	12,583	24.4
1922	796	10,957	7.3	1934	3,473	12,434	27.9
1923	1,034	11,543	9.0	1935	3,322	11,269	29.5
1924	1,005	10,272	9.8	1936	3,300	10,635	31.0
1925	1,224	11,248	10.9	1937	4,768	13,486	35.4
1926	1,480	11,325	13.1	1938	3,867	10,278	37.6
1927	2,326	13,072	17.8				

TABLE 2.—*Frozen-egg production, 1921-37*[1]

Year	Total frozen-egg products	Shell-egg equivalent	Year	Total frozen-egg products	Shell-egg equivalent
	Million pounds	*Million cases*		*Million pounds*	*Million cases*
1921	46	1.3	1930	185	5.3
1922	49	1.4	1931	152	4.3
1923	71	2.0	1932	138	3.9
1924	57	1.6	1933	171	4.9
1925	79	2.3	1934	198	5.7
1926	92	2.6	1935	206	5.9
1927	129	3.7	1936	208	5.9
1928	148	4.2	1937	[2]225	6.4
1929	155	4.4			

[1] 1921-36 unpublished estimates made by U. S. Tariff Commission, based on original entry into cold storage.
[2] "Production of Frozen Eggs in the United States in 1937," Poultry Section, Agricultural Adjustment Administration.

EFFECTS OF CONTRACT SYSTEM ON FROZEN-EGG PRICES

An important element in the price structure of frozen-egg products[4] is the contract system under

[4] The prices for frozen-egg products used throughout were obtained from the Egg-Drying Industry in the United States, U. S. D. A., Agricultural Adjustment Adminitration, Bulletin PSM-1. Series available from 1926 through May, 1937 only.

which a large proportion of eggs is broken. It is common for breakers to make contracts with buyers for the quantity of egg products which will be needed during the ensuing year on the basis of prices paid for shell eggs and operating costs during the egg-breaking season. Carrying charges of approximately $\frac{1}{4}$ cent a month per pound are added from August 1 through the following spring. Well-informed individuals estimate that from 75 to 80 percent of the frozen-egg supply is produced

TABLE 3.—*Comparative costs of processing and storage of shell and frozen eggs*

Items of cost	Cost per dozen eggs
	Cents
Shell Eggs[1]	
1. Into-storage candling, and packing materials	1.00
2. Storage charges, warehouse rental, interest, etc. for 8 months	2.70
3. Out-of-storage candling	.30
4. Loss and depreciation (6 eggs per case at 24 cents per dozen)	.40
Total cost for storing as shell eggs	4.40
Frozen Whole Eggs[2]	
1. Candling and breaking	2.00
2. Carrying charges, at $\frac{1}{4}$ cent per pound per month, for 8 months (1 dozen eggs yield 1.1667 pounds of whole eggs)	2.33
3. Frozen-egg cans (15 cents per 30-pound can)	.58
Total cost for storing as frozen whole eggs	4.91

[1] "The Egg-Drying Industry in the United States," Bulletin PSM-1, Agricultural Adjustment Administration.

[2] Computed from private sources.

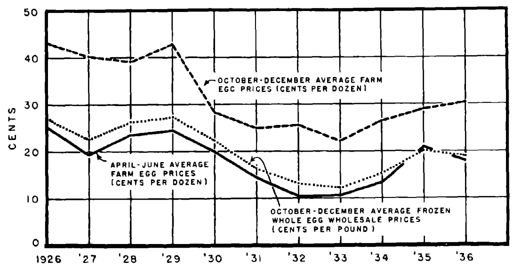


FIGURE 2.—Relationship between shell and frozen egg prices for selected seasons, 1926–36. The price of frozen whole egg in the fall is dependent on the price of shell eggs in the spring, but shows little relationship to the price of shell eggs in the fall.

and sold on the contract basis, but it is impossible to verify this.

The relationship between fall prices of frozen whole eggs and farm prices of shell eggs in the spring and in the fall is shown in figure 2. As would be expected from the nature of the contract under which most frozen eggs are sold, fall frozen whole-egg prices are considerably more dependent on shell-egg prices at the time the eggs are broken than when the frozen eggs are sold. This is shown by the rather constant relationship between October-December frozen-egg prices (dotted line) in figure 2 and the April-June farm shell-egg prices (solid line). Fall frozen-egg prices are poorly correlated with October-December farm shell-egg prices (dashed line).

Frozen-egg prices do not advance seasonally to the extent that shell-egg prices advance. While carrying charges of frozen eggs are approximately $\frac{1}{4}$ cent per pound per month, average prices of frozen whole eggs during October-December averaged only $\frac{1}{2}$ cent per pound higher than average farm prices of shell eggs during April-June in the 11-year period from 1926 through 1936.

RELATIONSHIP BETWEEN PRICES OF FROZEN-EGG PRODUCTS

Frozen whole eggs usually represent about half the holdings of frozen-egg products, the remainder being albumen and yolk separately. Yolks are classified as plain, salt, and glycerine yolk. No constant relationship exists between values of the various types. Prices of one type may fluctuate

TABLE 4.—*Relative prices of frozen yolk and frozen albumen to prices of frozen whole eggs, March-June, 1926–37*

Year	Yolk price	Albumen price	Average
	Percent	*Percent*	*Percent*
1926	105.7	91.6	98.6
1927	128.8	80.9	104.8
1928	147.8	52.2	100.0
1929	156.3	46.9	101.6
1930	137.3	64.3	100.8
1931	131.6	78.9	105.2
1932	140.0	82.5	111.2
1933	154.1	56.6	105.4
1934	147.1	65.7	106.4
1935	132.8	72.0	102.4
1936	132.8	66.7	99.8
1937	137.1	65.5	101.3

materially without regard to fluctuations in prices of frozen whole eggs or shell eggs.

Ratios of prices of frozen yolk and frozen albumen to prices of frozen whole eggs for the period March through June are shown in table 4.

While the ratio of yolk value to whole-egg value has varied from 105.6 to 156.3, the fluctuation is less than in the ratio of albumen value to whole-egg value which has varied from 46.9 to 91.7. The coefficient of variation[5] in the series of yolk ratios is 9.5 while in the series of albumen ratios it is 18.8. When one ratio is high, the other is low; although when albumen prices decline they tend to decline more than yolk prices advance, and, in rising, tend to rise more than yolk prices decline. The average of the two ratios approximates 100, as would be expected since frozen eggs can be reconstituted from yolks and albumen.

The amount that frozen-yolk and frozen-albu-

[5] The coefficient of variation $= 100 \frac{\text{standard deviation}}{\text{mean}}$.

men prices are above or below frozen whole-egg prices is shown in figure 3. This illustrates the inverse correlation between yolk and albumen prices. When yolk prices increase in relation to frozen whole-egg prices, albumen prices decrease approximately the same degree. Likewise, when yolk prices decrease in relation to frozen whole-egg prices, albumen prices increase. This relationship is due to the fact that albumen is to some extent a byproduct of the production of yolk and that an increase in the demand for and the price of frozen yolk causes an increase in the production of albumen and a consequent decrease in albumen prices. This illustrates one of the major problems of the frozen-egg industry—that of disposing of surplus albumen. Apparently, some new uses

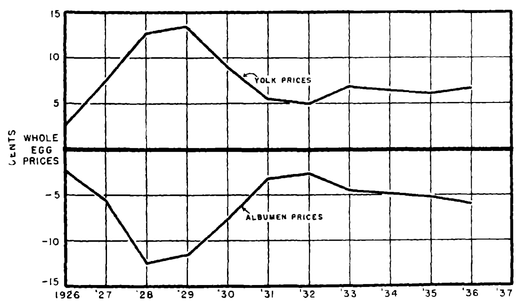


FIGURE 3.—Amount frozen yolk and frozen albumen prices are above or below frozen whole egg prices, 1926–36. (Annual average prices in cents per pound.) The inverse correlation between frozen-yolk and frozen-albumen prices is due to the fact that albumen is to some extent a byproduct of the production of yolk.

for albumen must be developed if this relationship is to be changed.

Prices of whole eggs as reconstituted from prices of albumen and yolk are illuminating. Table 5 shows average prices of frozen albumen, yolk, and whole eggs from April through March of the following year and whole-egg prices reconstituted from frozen yolk and albumen.

While albumen and yolk can be reconstituted to make whole eggs, frozen whole eggs cannot be satisfactorily broken down into yolk and albumen. In only one of these years, 1928, was the price of frozen whole eggs significantly higher than the price of reconstituted whole eggs. Throughout most of that year, the proportion of albumen to frozen eggs was at record-high levels which forced albumen prices to very low levels while yolk prices were rising.

SUMMARY

The breaking and freezing of eggs started early in this century as a method of utilizing undergrade eggs. A change in emphasis occurred in 1927, when breakers began using better quality eggs as shown by the change in the frozen-egg into-storage period.

The industry has grown from one producing 3 percent of the total storage holdings in 1916 to one representing 38 percent in 1938. Estimates indicate that about 6,500,000 cases of eggs were utilized in 1937 by this industry. Higher quality eggs and better handling and merchandising

TABLE 5.—*Average prices of frozen albumen, yolk, and whole eggs and prices of reconstituted whole eggs, per pound, 1926–37*

Year (beginning April)	Frozen whole egg	Reconstituted whole egg[1]	Frozen yolk	Frozen albumen
	Cents	*Cents*	*Cents*	*Cents*
1926	26.8	26.6	30.1	23.7
1927	22.7	23.0	32.1	15.5
1928	25.8	24.4	39.0	12.4
1929	26.6	26.7	39.6	16.2
1930	22.0	22.1	30.1	15.5
1931	15.9	16.6	20.7	13.2
1932	12.4	12.9	17.5	9.2
1933	12.3	13.3	19.8	7.9
1934	15.1	15.2	21.2	10.2
1935	19.5	19.4	25.7	14.2
1936	18.6	18.3	25.6	12.4

[1] Shell eggs consist of 45 percent yolk and 55 percent albumen. The reconstituted whole-egg price was converted on this basis.

methods have aided in its growth, but an increasing use of prepared foods probably has been the most important factor. There is little cost advantage to either frozen or shell eggs, the principal advantage of frozen eggs being convenience to the user.

The contract system under which most eggs are broken is an important price factor. For this reason, frozen-egg prices in the fall are closely related to farm shell-egg prices in the spring. Prices of albumen fluctuate more widely than yolk prices. There is an inverse correlation between albumen and yolk prices, probably because albumen is to some extent a byproduct of the production of yolk. Reconstituted frozen whole-egg prices are closely related to actual frozen whole-egg prices.

EVISCERATION AND QUICK FREEZING OF POULTRY IN THE UNITED STATES

By THOMAS W. HEITZ, *Marketing Specialist, Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C., U. S. A.*

The marketing of eviscerated poultry, that is, poultry that has had entrails, head, and feet removed, is not a new development in the United States. Almost ever since poultry began to be marketed in a commercial way, some drawn poultry has been sold. But until the last few years this method has been confined chiefly to the sale of poultry so prepared in local shops—not at the source of production. Where this general practice was followed, the housewife would buy the poultry undrawn and with head and feet on, and after the sale was made the poultry would be drawn by the retailer or butcher before it was delivered to her.

EXPANSION OF THE PRACTICE

Experimental work in drawing poultry at country packing plants and shipping it full drawn to distant markets was undertaken on a somewhat elaborate scale in the latter part of 1927. Such poultry was so well received in the cities that it was believed all poultry would soon be marketed in this way. In 1928 several packing firms, including some of our largest poultry packers, engaged in this practice and for a year or two considerable quantities of poultry were marketed in this way. As a result of the adoption in some cities of health ordinances which required that the poultry be inspected by a Federal or State agency before it be sold, many plants adopted Government inspection in 1929. This held true not only for the plants that were selling their poultry in a frozen state but also for the plants that were preparing poultry for canning.

Enthusiasm for the frozen eviscerated poultry practically disappeared by 1931 in spite of the fact that the poultry-canning industry had a growth that was more or less steady, although slow. The methods and equipment in general use and an apparent lack of accurate knowledge as to just how to prepare the poultry were not conducive to placing a high-grade and wholly sanitary product on the market. There was little knowledge of quick freezing. Moreover, the facilities for quick freezing were not available even had it been desired. Retail stores were not then equipped with refrigerators capable of keeping the poultry in a frozen state and it was not fully appreciated that eviscerated poultry must be kept frozen through all subsequent channels of distribution. Experiments made by the Bureau of Chemistry of the United States Department of Agriculture 20 years or more ago had indicated that the keeping quality of undrawn poultry was better than that of drawn poultry. This was true, of course, because of the limited facilities for and knowledge of freezing.

With the advent of quick freezing, conditions began to change. Furthermore, later investigation by the United States Department of Agriculture showed advantages in storing full-drawn ducks over undrawn ducks.

In the later experimental work it was found that the development of fatty acid was considerably less in drawn ducks that had been stored for several months than it was in the undrawn ducks. The bacteria count was several times greater in the undrawn ducks than in the eviscerated ducks that had been quick frozen.[1]

Further tests of the eating qualities of the ducks have shown a decided superiority of the full-drawn quick-frozen product over the undrawn product after each had been in cold storage 6 months. In these tests the factors considered were flavor of the fat, flavor of the lean meat, tenderness, aroma, and quality and quantity of the juice.

The development and consumer acceptance of frozen foods, especially fruits and vegetables, in the last few years have shown a remarkably successful expansion. This has led to the installation of freezer cabinets in a great many of the retail stores and has made available better facilities for handling quick-frozen poultry. An expanded marketing of quick-frozen poultry has developed rapidly and it seems that the industry is headed toward a more sound and stable development than it has shown in the past.

The growth of poultry inspection from 1929 to 1937 inclusive is shown in table 1. In the last two years about three-fourths of the poultry shown in the table was eviscerated for canning: the remainder, for selling in its frozen state.

ADVANTAGES OF THE PRACTICE

There are several decided advantages in marketing quick-frozen drawn poultry over selling undrawn poultry that has been frozen by the slower methods. The main advantage is the higher grade product resulting from the removal of the entrails, heads, and feet before storage. The taste or flavor of the entrails is not noticeable in the full-drawn product. It is difficult to detect the difference between a fresh-dressed chicken and a quick frozen full-drawn chicken even after the latter has been stored 6 months in a cold storage room.

The drawing of poultry at the shipping point—where modern equipment, more skilled employees,

[1] Reports of experiments by Swenson and Heitz in 1932 show a bacteria count of an average of 2,016,000 per cubic centimeter of flesh in ducks that had been undrawn, commercially frozen, and stored for 6 months, compared with a bacteria count of 64,000 per cubic centimeter in ducks that had been eviscerated, quick frozen, and stored for the same length of time. The undrawn ducks showed 1½ percent acidity of fat compared with 0.28 percent in the drawn, quick-frozen samples. (U. S. Egg and Poultry Magazine, November, 1933, Page 36.)

and more sanitary conditons are available—means a superior product and a uniform product. There it is possible to make better "preparation" and more attractive packages than is usually the case where the poultry is drawn at the butcher shop or retail store.

Immediate freezing of the drawn birds at low temperatures preserves the quality of the meat, checks any tendency toward deterioration in the product, and makes possible the holding of the poultry in excellent condition until sold. Smaller packages can be used when the heads and feet are removed; and the saving in freight rates of about 25 percent is an item of tremendous importance to the poultry industry. About 25 percent further saving can also be made in storage costs when this poultry is stored before being sold.

The fact that labor costs are considerably lower at country packing plants than they are in the terminal markets is worth remembering.

Because of the large volume of poultry handled, Government veterinary inspection is possible at the country-shipping points. This eliminates the possibility of consumers eating poultry that was diseased when drawn and is an assurance to the housewife of the wholesomeness of the product she is using if it has been kept properly after it was bought. The cost would be prohibitive if inspection were to be obtained at the individual retail stores.

TABLE 1.—*Poultry (dressed) inspections for condition and wholesomeness*

Calendar year	Pounds certified	Pounds rejected	Total pounds inspected	Percent rejected
1929	19,889,961	812,055	20,702,016	3.9
1930	21,573,446	997,954	22,571,400	4.4
1931	15,213,226	773,013	15,986,239	4.8
1932	14,022,935	492,772	14,515,707	3.3
1933	14,848,566	468,173	15,316,739	3.1
1934	17,923,295	538,147	18,461,442	2.9
1935	22,750,282	515,808	23,266,090	2.2
1936	32,253,904	697,488	32,950,582	2.1
1937	42,839,856	738,913	43,578,769	1.6

Table 1 shows the percentage of inedible poultry that was condemned as unsuitable for food during 8 years of inspections made on a voluntary basis. It is reasonable to suppose that this would probably have been sold and eaten if the poultry had not been inspected.

The appearance of full-drawn poultry which is usually individually wrapped in cellophane is much more attractive than an individually wrapped chicken with the heads and feet attached. This attractive appearance, which is the aim of the more careful packers, is doing much to promote consumer acceptance of the full-drawn product.

The utilization of the byproducts that result from the drawing of quantities of poultry in some places provides a small revenue. This would not be possible in retail shops because of the small quantity of poultry handled.

From the housewife's point of view, the poultry so prepared is ready to cook. No work or worry of cleaning on her part is necessary. In contrast to the old way of choosing an undrawn bird and then waiting for the butcher to draw and prepare it, a housewife now, with the expenditure of a minimum amount of time and trouble, can buy a fowl at the store already packaged and with the net weight stamped on the package.

DISADVANTAGES OF THE PRACTICE

There are, of course, some disadvantages. Perhaps the most serious is the seemingly high price per pound the housewife must pay when she buys the poultry full drawn. When the poultry is sold undrawn and with head and feet attached, it can be sold at considerably less per pound than can poultry from which approximately 25 percent of the inedible portion has been discarded. This together with somewhat greater labor and package costs, must be added to that price per pound at which the poultry is sold. At first thought this makes the poultry seem expensive to the housewife, but in markets where there have been concentrated sales efforts to promote the sale of this kind of poultry, it has been found that most consumers quickly come to like the saving in waste in buying the full-drawn ready-to-cook poultry and have come to realize that there is but little difference in the price of the actual edible portions of the meat between the full-drawn and the undrawn product.

TABLE 2.—*Percentage of inedible portions of various types of poultry*

Type of poultry	Inedible portions
	Percent
Broilers, light	31.00
Broilers, heavy	28.50
Fryers	27.40
Roasters	24.25
Fowl, medium	26.25
Ducks	27.50
Geese	28.00
Turkeys, hen	16.50
Turkeys, tom	15.00

Any new idea in food merchandising is developed slowly. Even though consumer education will probably make full-drawn poultry not only acceptable but demanded by housewives, the educational process must come first. This fact has retarded and, to an extent, will retard the development of the merchandising program.

The percentage of inedible portions of various types of poultry as prepared by commercial packers for selling frozen and for canning is shown in table 2. These data were taken from the reports of several of the leading packers of the country and form a record of dressing loss incurred in preparing approximately 5,000,000 pounds of poultry.

Other retarding factors have been the cost of Government supervision at the poultry packing plants and the loss accruing from the condemnation of diseased poultry. These are considerable items of expense in a year's time, but the cost if figured on a poundage basis is very small—in most cases it is only a fraction of a cent per pound. Certainly the discard of the diseased parts is not a loss to society as a whole.

In spite of the fact that drawn poultry requires smaller package space than the same number of undrawn poultry, the cost of packaging the full-drawn product is greater than that of packing the undrawn product, because the packers have adopted a more attractive and more expensive package. Practically all of the packers who merchandise full-drawn poultry are wrapping each bird individually in cellophane or in a stockinette covering which adds somewhat to the cost of preparation. Most packers figure that the labor of eviscerating and the cost of packaging will vary from $1\frac{1}{2}$ cents to $2\frac{1}{2}$ cents per pound, depending on class, grade, and weight of the bird. The poultry is usually packed six birds to the box, compared with 12 birds to the box when the poultry is undrawn.

The seasonal nature of the packing operation is also more or less of a problem at present. For instance, the broiler season lasts only 2 or 3 months. During this time the packers are forced to anticipate what their requirements will be until the next season's supply is available. This leads to considerable speculation as to how many broilers should be drawn and prepared. If too many are drawn and carried in cold storage into the next season, there is always the chance of lower market prices, which could mean considerable financial loss to the storer of the poultry.

METHOD OF QUICK FREEZING

The quick freezing is accomplished by three different processes or methods of operation. The first process to come into use in the freezing of poultry does the work by placing the poultry in close contact with metal containers of the refrigerating medium. In this manner cold is conducted immediately to the flesh of the bird. In this process a temperature of approximately minus 40 degrees Fahrenheit is used, and will freeze poultry solidly in from 2 to 3 hours, depending on the size of the bird. Another process freezes the bird in practically the same length of time, using the medium of salt brine sprayed as a fog directly on the birds, which have been placed in metal cabinets. The temperature used by this method is approximately minus 5 degrees Fahrenheit. The third and simpler method of freezing consists simply in placing the birds, after packaging, into cold storage rooms of very low temperature. The temperatures used by most of the packers who have adopted this method range from minus 20 degrees Fahrenheit to minus 50 degrees Fahrenheit; although freezing is not accomplished so quickly as in either of the other methods, it is a great improvement over the methods used when poultry was frozen at zero temperatures.

The sanitary requirements of the plants that are operating under Government supervision and inspection are quite rigid. These requirements apply not only to sanitary conditions in the plant but also to methods of operation. Each carcass as it passes in a movable individual tray before the inspector is carefully examined by him before the entrails are removed. The trays are sterilized with hot steam before each use, all knives and operating equipment are sterilized frequently, and the building is washed and thoroughly cleaned at frequent intervals. Every effort is made to insure genuine sanitation.

SUMMARY

Prior to 1928, the housewife who wanted to buy eviscerated poultry would buy the poultry undrawn, with head and feet on, and have the bird drawn in the butcher shop. Most housewives continue to buy poultry in this manner but an increasing number prefer poultry which has been eviscerated and quick frozen at country packing plants. Development of this innovation in poultry marketing has been very slow, but there has been a gradual increase in the amount of poultry eviscerated for canning and for sale in the raw state. Eviscerated poultry inspected for condition and wholesomeness by Government inspectors including poultry for canning has increased from 3,000,000 pounds in 1928 to 43,600,000 pounds in 1937.

One of the chief advantages in selling full-drawn or eviscerated poultry which has been Government-inspected is the assurance given the housewife that the poultry is free from disease and that it has been prepared in plants much more sanitary than the ordinary butcher shop in which poultry is drawn. On the other hand, the apparent high price per pound at which drawn poultry must be sold in comparison with the undrawn has resulted in sales resistance which must be overcome by consumer education. The shrinkage in weight from removal of head, feet, entrails, and inedible portions amounts to from 15 percent on tom turkeys to 33 percent on small broilers. This loss from shrinkage must be compensated by a higher price per pound on the edible parts, and it makes poultry so priced seem high in comparison with undrawn poultry.

With the improvement in quick-freezing processes and with better facilities for handling quick-frozen poultry in the retail stores and in the homes, this method of merchandising poultry should expand steadily because of the superiority of the frozen product in comparison to the storage poultry of a decade ago. The entrail taint is entirely absent, even after several months of storage, and because the birds are solidly frozen within two or three hours after drawing, more of the original bloom and flavor is retained.

ZIEL UND TECHNIK DER VORRATSWIRTSCHAFT BEI EIERN UND SCHLACHTGEFLÜGEL

Von Dr. A. Lange, *Reichsstelle für Eier, Berlin, Deutschland*

Da alle Bemühungen um verstärkte Legetätigkeit des Huhns im Herbst und Winter in Deutschland wie im Ausland vorläufig nichts daran ändern, dass der grössere Teil des Eieranfalls sich auf die Frühjahrsmonate zusammendrängt, ist die Vorratswirtschaft einer der Hauptpfeiler der deutschen Marktordnung. Dabei heisst Marktordnung nichts anderes als: mit dem Vorhandenen so auszukommen, dass möglichst die Gesamtheit aller Volksschichten eine annähernd gleichmässige Versorgung geniesst.

Die wirtschaftliche Seite der deutschen Eiervorratswirtschaft unterscheidet sich nicht unerheblich von den gleichartigen Bemühungen anderer Länder. Vorsausgeschickt sei nochmals, dass jedes in Deutschland zum Verkauf gelangende konservierte oder Kühlhausei als solches ("K" oder "konserviert") gekennzeichnet sein muss. Auch in anderen Ländern legen zwar die Grossimporteure einen mehr oder minder bedeutenden Vorrat auf eigenes Risiko hin, bei uns jedoch wird vor Beginn der Eierschwemme eine Gesamtkalkulation angestellt über die Mengen, die aus eigener Erzeugung und aus fremden Lieferungen während des Jahres zu erwarten sind. Aus der Tatsache, dass die deutsche Eiereinfuhr gegenüber früheren Jahren halbiert ist, ersteht die Notwendigkeit, mit dem Vorhandenen stärker hauszuhalten, mit einem Wort: beträchtliche Teile der Frühjahrseinfuhr und ein grosser Teil der eigenen Frühjahrserzeugung gehen ins Kühlhaus. Diese für den Vorrat bestimmten Mengen berühren nicht den Markt; im Ausland werden sie von vornherein als kühlbearbeitete Ware gekauft und entsprechend disponiert, im Inland werden sie auf Grund langfristiger Lieferungsabkommen gleichfalls unmittelbar von der Packstelle an die Kühlhausrampe gerollt.

Die vollkommene Steuerung des Marktes hat es mit sich gebracht, dass diese Vorratshaltung zentral, d. h. in einer einzigen Hand, und zwar bei der Reichsstelle für Eier, sein muss. Weil einmal das Kühlhausei als solches gekennzeichnet ist und als solches verkauft werden muss, also irgendein Anreiz zur Erzielung spekulativer Zwischen- und Sondergewinne nicht besteht und die zentrale Hand selbst der Verkäufer ist, kann das Kühlhausei als ein preiswertes Konsumei zum Festpreis abgegeben werden, kann schliesslich der zentrale Vorrat so gestreckt werden, dass auch zu Weihnachten und für das neue Kalenderjahr ein genügend grosser Vorrat vorhanden ist.

Die Menge, die in dieser Weise zentral gehalten wurde, lag in den letzten Jahren zwischen 500,000,000 und 600,000,000 Stück Eiern im Jahr. Mit dieser bedeutenden Zahl ist bereits gesagt, dass eine ganze Reihe von technischen Konservierungsverfahren ausscheidet, nämlich jene Verfahren, die im Kleinen und im Haushalt geeignet sind. Einstweilen ist das normale Kühlungsverfahren, nämlich das Einbringen und Stapeln in der Kiste, das Kühlen bei null Grad in einer Feuchtigkeit zwischen 75 und 82 Prozent, die bewährte Methode. Aus der vorher erwähnten vorratspolitischen Linie heraus ergeben sich jedoch gegenüber der Kühlung in anderen Ländern einige Abweichungen. Wenn im allgemeinen die anderen Länder—soweit planmässig, nicht aus der Verstopfung des Marktes gekühlt wird—im April und Mai die Eier ins Kühlhaus bringen und im Oktober/November die Auskühlung im wesentlichen schon bewältigen und beenden, verlangt die Grösse des deutschen Vorrats bereits einen früheren Beginn, meist schon im März. Andererseits muss der deutsche Vorrat länger gehalten werden, ein Teil mindestens bis Dezember/Januar. Daraus erwächst die Notwendigkeit, trockener zu kühlen, um nämlich Verluste in den letzten Monaten so gering wie möglich zu halten. Nur nebenbei sei die internationale Erfahrung bestätigt, dass die einzelnen Herkünfte sehr verschiedene Eignung in der Kühlung zeigen, und zwar gilt das nicht nur für die Provenienzen im grossen, sondern auch für die Eier aus den einzelnen Bezirken Deutschlands. Wir stellen gerade in dieser Richtung Versuche an, um wissenschaftlich zu erweisen, ob die klimatischen Besonderheiten des Gebietes oder die Zusammensetzung des Bodens und der Fütterung oder alles zusammen die günstigen bzw. ungünstigen Faktoren abgeben. Weiter ist bei uns aus der Notwendigkeit, die Eier lange zu halten, eine besonders grosse Beachtung der Verpackung entstanden. Wir haben gefunden, dass neben der bewährten Flachkiste zu 720 Eiern die Viertelkiste zu 360 Eiern (Holzkiste mit Fächerpappe aus reinem Holzschliff) als gleich bewährt gelten kann, wenn die einzelnen Fächer des Kartons Ausschnitte in Kreis- oder Halbkreisform zum Zwecke der grösseren Luftdurchlässigkeit haben. Leider ist hier nicht der Raum, um auf die weiteren Methoden der Eiergrosseinlagerung einzugehen; in jedem Fall scheint die Gaslagerung, d. h. die Eierkühlung in Tanks bzw. Blechbehältern vielversprechende Ergebnisse zu zeigen. Diejenigen, die sich mit einer Vorratshaltung im grossen befasst haben, werden aber zugeben, dass die arbeitstechnisch komplizierte Behandlung von 500,000,000 bis 600,000,000 Eiern in Gastanks wohl in jedem Lande auf fast unüberwindliche Schwierigkeiten stösst. Geht man davon aus, dass die Mängel bei der bisherigen Kühlung vorzugsweise in der Bakterienentwicklung ab 5./6. Monat bestehen, dass ausserdem nach dieser Zeit sich jener unerfreuliche Ammoniak-Vorratsgeschmack beim Kühlhausei einstellt, so scheint eine bessere Lösung dieses Problems darin zu beruhen, dass zu der normalen Kühlung noch etwas hinzutreten muss: entweder ein vorausgehendes Bad in einer der verschiedenartigen, teilweise mit Erfolg ausprobierten Paraffinöl- usw. -lösungen oder die Gaszugabe in den normalen Kühlraum.

Der Ausgangspunkt der Vorratshaltung bei Geflügel ist zunächst ein ähnlicher wie beim Ei: auch hier bildet in Deutschland wie in anderen Ländern der stossweise gehäufte Anfall eine Gefährdung für die Stetigkeit des Marktes und mithin eine nicht erwünschte Beeinträchtigung des liefernden Geflügelhalters. Auch wenn ich die neuesten Verfahren, wie beispielsweise das in USA vielfach verwandte Birdsey-Verfahren, berücksichtige, ist die Methode noch immer die gleiche, wie sie schon seit Jahrhunderten in kälteren Zonen geübt wird, nämlich das mehr oder minder starke Einfrieren des Tieres. Über den Tiefengrad der Kälte ist freilich eine gewisse Erörterung entstanden. Bei unseren sich weit über ein Jahr erstreckenden grösseren Versuchen haber wir—und zwar vom Standpunkt der Praxis und des Grosseinlagerers aus—gefunden, dass zwischen $-10°$ und $-15°$ nicht nur die Haltbarkeit des Huhnes gewährleistet ist, sondern auch Geschmack, Aussehen usw. sich am besten halten. Wählt man tiefere Temperaturen, so zeigt sich nach sechs und mehr Monaten, dass Geschmack und die Festigkeit der Fleischfaser ziemlich schnell verloren gehen, lagert man bei Temperaturen zwischen $-5°$ und $-10°$, so ist die Haltbarkeit über ein Halbjahr hinaus in Frage gestellt. Wie auch beim Ei, ist die Anwendung besonderer Spezialverfahren, etwa eines Tauchverfahrens in Lösungen $-30°$ vorläufig noch nicht anwendbar für die Grosseinlagerung. Sie ist es um so weniger, solange Deutschland beispielsweise aus einer Vielzahl von Lieferländern Geflügel bezieht, das zum grösseren Teil schon als Schlachtegeflügel hereinkommt.

Es ist ohne weiteres zuzugeben, dass die Vorratstechnik beim Ei und beim Huhn in der weiteren Zukunft noch mannigfache Veränderungen erfahren wird; gar zu lange hat man diesen wichtigen volkswirtschaftlichen Umschlag sich selbst und dem vorzugsweise am Preis und an der Marktmanipulierung interessierten Handel überlassen. Man kann daher von einem näheren und einem weiteren Ziel in der Vorratstechnik sprechen; für Deutschland als dem zentral gelegenen Grossabsatzgebiet für Geflügel beispielsweise ist das nähere Ziel klar: möglichst saubere Bearbeitung in den Mästereien und Schlachtereien, Vermeidung des Brühens bzw. Nassrupfens beim Vorrats-Geflügel, Bereitstellung bester Kühlwaggons, Beschleunigung des Umschlages, Kühlung bei etwa $-15°$. Das weitere Ziel ist im grossen und ganzen erst noch Wunsch, die Versuche anderer oder verbesserter Konservierungsmöglichkeiten können nur im kleinen Versuchsrahmen von der Wissenschaft mit Unterstützung der Praxis durchgeführt werden.

ZUSAMMENFASSUNG

Ziel der deutschen Vorratswirtschaft für Eier und Schlachtgeflügel ist die möglichst gleichmässige Verteilung des deutschen und ausländischen Anfalls auf das ganze Jahr, um mit dem vorhandenen so auszukommen, dass möglichst die Gesamtheit aller Volksschichten eine annähernd gleichmässige Versorgung geniesst. Die zu diesem Zweck ergriffenen Massnahmen lassen sich wie folgt kurz zusammenfassen:

Im voraus fester Einkühlungsplan, systematischer Aufkauf im In- und Ausland, zentrale Einkühlung, planmässige Auskühlung während der eierknappen Zeit bei stetigem Verbraucherpreis.

Die in Deutschland angewandte Konservierungstechnik für Eier ist einstweilen noch das normale Kühlungsverfahren, nämlich das Einbringen und Stapeln in der Kiste und das Kühlen bei 0 Grad in einer Feuchtigkeit zwischen 75 und 82 Grad.

Im Vergleich zu anderen Ländern ergibt sich aus der Zielsetzung und aus der Grösse der deutschen Einkühlung—zwischen 500,000,000 und 600,000,000 Eier im Jahr—ein früherer Einkühlungstermin und ein späterer Auskühlungstermin und damit die Notwendigkeit, trockener zu kühlen. In der Verpackungstechnik wird neben der bewährten Flachkiste zu 720 Eiern die Viertelkiste zu 360 Eiern bevorzugt.

Beim Geflügel ist die Kühlmethode die schon seit Jahrhunderten in kälteren Zonen geübte, nämlich das Einfrieren der Tiere, wobei sich in Deutschland nach den sich weit über ein Jahr erstrecken den Versuchen herausgestellt hat, dass zwischen minus 10 Grad und minus 15 Grad nicht nur die Haltbarkeit des Huhnes gewährleistet ist, sondern auch Geschmack, Aussehen u.s.w. sich am besten halten.

SUMMARY

The goal of the creation of reserves of eggs and table poultry in Germany is the best possible and equal distribution of domestic and foreign products over the whole year, in order to use the available quantities economically, so that all classes may enjoy equal supply. The measures adopted for this purpose may be summarized as follows:

Prearranged cooling plans, systematic purchase at home and abroad, central regulation of the accumulation of reserves and planned distribution at a fixed price to the consumer at the time when eggs are scarce.

The technique used in Germany for storing eggs is, at least for the time being, still the normal cooling process, namely, the transporting and storing in cases and cooling at 0° Celsius, with a humidity between 75 and 82 percent.

Due to the purpose, and extent of the creation of reserves in Germany—between 500,000,000 and 600,000,000 eggs annually—our procedure is some-

what different from that of other countries; the accumulation of reserves must begin earlier and the distribution must be extended over a longer period, which requires cooling at a lower relative humidity. With regard to the technique of packing it is to be said that, besides the practical case with 720 eggs, the quarter-case with 360 eggs is considered as very suitable.

The method of cooling poultry, freezing the birds, has been used for centuries in the colder regions. During experiments carried out in Germany extending over a period of more than a year, it has been found that temperature of $-10°$ and $-15°$ Celsius guarantee the preservation not only of the chickens but also of the taste, appearance, and other quality factors.

MERCANTILE EXCHANGES IN THE POULTRY AND EGG INDUSTRIES

By LLOYD S. TENNY, *Manager, Chicago Mercantile Exchange, Chicago, Illinois, U. S. A.*

Mercantile exchanges providing facilities for spot and futures trading in eggs or poultry are institutions known only in the United States. These Exchanges provide meeting places for the trade to buy and sell, set up trading rules under which the business operates and police all contracts entered into on such Exchanges. Goods delivered in fulfillment of all such contracts are inspected and passed by employees of the Exchanges. The Exchanges, as institutions, buy and sell nothing and have no direct interest in the prices registered from day to day.

The price of any commodity for any specified day may best be determined by actual buying and selling of goods. Exchanges offer the most satisfactory machinery for such price determination. The Chicago Mercantile Exchange has member and nonmember customers throughout the entire United States. The current offerings and bids are distributed widely by an Exchange ticker service, by private wires, by telegraph and telephone, with the result that prices do reflect very promptly the opinion of the trade, resulting in actual sales completely policed by a neutral agency. No other system of registering prices has been developed that so quickly or so completely reflects the age-old law of supply and demand.

The volume of cash trading on our exchanges is sufficient to justify the belief that our daily quoted markets are based on real transactions. Figures are not available to indicate the total cash value of commodities sold on the New York Mercantile Exchange during a full year period, but in 1938 there were 589,667 cases handled on that cash market. On the Chicago Exchange cash market the total amount of business in 1938 reached the surprisingly large sum of $19,518,120.19. Purchases during last year were heavier than usual due to the heavy buying of butter by Government agencies. In 1937 cash sales of eggs in Chicago totaled $636,974.63. A relatively large number of other cities throughout the country have butter and egg exchanges and these exchanges confine their operations entirely to cash trading.

FUTURES TRADING ON THE EXCHANGES

The Exchanges in Chicago and New York provide contracts for future delivery. It is of this futures trading that I desire now to speak. Probably no feature of marketing agricultural products is less understood or more criticised than futures, this in spite of the fact that nothing in the process of marketing eggs is of so great value to producers of eggs as an active futures market. In order to understand the proper functioning of a futures market, it is necessary to establish some fundamental facts.

Eggs are produced throughout the year but, during the spring period, the natural habits of the hen result in a peak production—far beyond the demands of consumers to use. This so-called surplus is not necessarily a surplus figured on an annual basis for, during the fall and winter months, fresh supplies are not sufficient to meet the demand. Due to the development in the United States of an unusually efficient system of refrigeration, this heavy production in the spring is stored for winter consumption. This temporary surplus is a necessary part of our marketing system. The proper handling of it brings higher prices to our producers during the heavy production period and, at the same time, makes it possible for a great mass of our consumers to have good eggs at a reasonable price during the deficit producing months. The storing of 6,000,000 to 8,000,000 cases of eggs presents some difficulties, however, and here a futures market fits into the picture.

A car of eggs on track in Chicago, purchased in the spring for storage to be sold several months later, represents a definite cost to the owner. The market situation, to be perfect, should show a gradually increasing price from the storing period to the time the car moves into consumption. This perfect market behavior seldom takes place. If too many eggs are stored, based on all the factors of supply and demand, the price will inevitably go down and the owner takes a loss. This speculation cannot be avoided. Every case of storage eggs involves a price risk. Surplus eggs stored during March, April, and May are worth only what the consumer will pay six months later, but no one knows, in the spring, what prices will prevail in the fall. In 1937 the storage egg crop sold for from $15,000,000 to $20,000,000 less than cost.

A futures market does not and cannot eliminate this price risk, but it does set up the machinery whereby the merchant buying the eggs can eliminate this risk from his own operations. It, therefore, keeps these merchants solvent and thereby gives to the purchasers year after year a buying power ever ready to absorb the next year's surplus egg crop. Perhaps no better explanation of the use of a futures contract can be made than to describe briefly this process of hedging by enumerating the steps taken by a merchant to protect himself against the hazards of price fluctuation.

HEDGING PROCEDURE AND RESULTS

In April, merchant A buys a car of storage-packed eggs on track in Chicago. At the same time he sells a futures contract of Refrigerator Standards for October delivery. His selling price should be sufficiently above the original price to cover storage and incidental charges plus a small profit. In making the sale, he knows he can have the car graded the following October and make delivery in fulfillment of his futures contract. Being a merchant with regular customers to supply with eggs in October, he knows, however, that he will probably not make delivery but will satisfy his contract on the Exchange by making a purchase in October when his customer wants the car of actual eggs.

The sale price of the actual car of eggs in October will be based on the price at which the October futures contract can be bought, but usually is a quarter or a half cent above the contract. Under this plan, merchant A is amply protected against loss if the price of eggs drops but, likewise, his profits are limited if the price advances. An accounting of many kinds of cars handled in this manner shows that merchant A can operate year after year with a profit of from $60.00 to $80.00 per car. Under this hedging plan, the banker can well afford to make generous loans to merchant A, these loans being supported by warehouse receipts and with the understanding that merchant A uses a futures exchange for hedging purposes.

In order to illustrate the hedging program, let me present two actual examples, the first, in 1937, on a car of eggs which was sold at a substantial loss; the second, in 1938, also a car of eggs in which case the goods themselves were sold at a profit.

Hedging as a protection against loss

On April 27th, 1937, merchant A bought a futures contract of May Storage Packed fresh eggs at 22¼ cents. In order to simplify the illustration as much as possible, let us follow this car of cash eggs. On May 10th the car was delivered to merchant A, the car being located on the Chicago & Great Western railroad tracks and, of course, cost merchant A 22¼ cents. This car was stored in a cold storage warehouse in Chicago under lot number E 3172 and went into storage on May 12th, 1937. On October 26th following, the car was sold to a wholesale distributor at ½ cent over the going October futures contract price on that date. This resulted in a billing price on the car of eggs of 19 cents. The transaction, including all costs was as follows:

Cost of original car—12,000 dozen at 22¼ cents...	$2,670.00
Add clearing fees of original long commitment.	1.10
Storage—400 cases at 37 cents each............	148.00
Insurance—$.02 per $100.00 per month.........	3.20
Cost of reinspection..........................	6.00
Interest at 4 percent.........................	50.04
Clearance fees, October commitment..........	2.20
Total cost................................	2,880.54
Less proceeds of sale—12,000 dozen at 19 cents..	2,280.00
Net loss without hedging operation........	600.54

This $600.54 represents the actual speculative loss involved in carrying this car of storage eggs from approximately the middle of May until the end of October. Without a futures market this would have represented the exact financial status on this particular car to merchant A.

However, as has been indicated, on April 27th, when the original purchase contract for eggs was entered into, a futures in the October contract was sold at 24⅛ cents. This resulted in a spread of 1⅞ cents per dozen between the purchase price and the hedging sale. This 1⅞ cents per dozen had to cover storage, interest, insurance, and other incidental expenses. On October 26th, when the car of actual eggs was sold to the distributor at ½ cent over the October contract, merchant A bought a contract of October eggs at 18½ cents. This purchase of the October contract was used by the merchant to offset his earlier sale of a futures and took him entirely out of the futures contract, leaving him with the car of eggs again in his possession which he had already sold on that day to the wholesaler. The hedging transaction resulted, therefore, as follows:

Car sold on Apr. 27th, 12,000 dozen at 24⅛ cents.	$2,895.00
Car purchased on Oct. 26th, 12,000 dozen at 18½ cents..................................	2,220.00
Hedging profit...........................	675.00

Merchant A, therefore, finds himself in the position of having made $675.00 hedging profit against which is a loss of $600.54 on merchandise, leaving him a net profit of $74.46 or slightly more than ½ cent per dozen.

Hedging as a limitation of profit

The second example is identical except that on April 16th, 1938 a car of storage-packed eggs was bought on the spot call of the Chicago Mercantile Exchange at 19¼ cents. On the same day an October futures was sold at 20⅞ cents which resulted in a spread of 1⅝ cents. This, incidentally, is a rather narrow spread and the results of the entire transaction were, consequently, not as satisfactory. The car bought was on the Wabash railroad and was stored in a cold storage warehouse under lot No. 1593 on April 18th, 1938. The car of actual eggs was sold to a wholesaler on October 15th at $\frac{3}{8}$ cent over the October contract price. The October futures sale was closed out on that day by the merchant at $24\frac{3}{4}$ cents. Therefore, the car was billed to the buyer at $25\frac{1}{8}$ cents. Following is a résumé of the transaction:

Cost of original car—400 cases, 12,000 doz. at $19\frac{1}{4}$ cents	$2,310.00
One-half cost of original inspection	3.00
Storage—400 cases at 37 cents each	148.00
Insurance—$.02 per $100.00 per month	3.23
Cost of re-inspection	6.00
Interest at 4 percent	46.72
Clearing fees	2.20
Total cost	2,519.15
Less proceeds of sale—400 cases, 12,000 doz. at $25\frac{1}{8}$ cents	3,015.00
Net profit before hedge loss	495.85
Less hedge loss—12,000 dozen sold at $20\frac{7}{8}$ cents and purchased at $24\frac{3}{4}$ cents	465.00
Actual profit on car	30.85

On this particular car, the profits on the entire transaction amounted to only $30.85 in spite of the fact that the goods themselves made a profit of $495.85.

It can be seen from these two illustrations that merchant A eliminated the speculative risks involved in price change, and while he is safeguarded against loss, his profits, likewise, are limited. Hedging simply safeguards the operation of the merchant.

Again I desire to emphasize the fact that this method of handling eggs does not eliminate the speculation involved in price fluctuation. This speculation cannot be removed. Hedging simply provides a means whereby the merchant who buys from country packers refuses to assume this risk and, by using a futures market, turns this speculative risk over to the public or to that portion of the public which makes a specialty of buying price risks. Again it is well to say that the producer of eggs is benefited most by this process of hedging.

POSITION OF THE EXCHANGES IN THE MARKETING SYSTEM

It is too much to expect that the full meaning of a futures market or the details of a hedging process can be given in one brief paper. It is hoped, however, that sufficient has been given to stimulate an increased interest in Exchanges. Every student of futures trading has pointed out its advantages. It provides a tool that is greatly needed in our industry and one which should be more widely used.

Exchanges have accomplished much in raising the standards of business ethics. Products themselves have been standardized. Millions of dollars worth of goods change hands annually under sets of rules that are fair to both buyer and seller. The practices on Exchanges are not only policed by the Exchange management but by the Federal Government through the Commodity Exchange Administration. In accordance with the Act of Congress, customers' monies are segregated in special bank accounts. Representatives of the Federal Administration are present on the floor of the Exchange and are available to make checks on any and all matters pertaining to futures transactions.

It can, therefore, be seen that Exchanges operating in produce lines are available for cash and futures trading. Open markets are provided. Any one, member or nonmember, can buy or sell either for immediate or future delivery. All operations are governed by definite rules published and distributed for public use. Every transaction is policed both by the Exchanges and by the Commodity Exchange Administration. Such open and competitive markets supply the best means known for establishing market prices. The use of such exchanges should be encouraged since the greatest possible good would come when trading is active and Nationwide in its scope.

SUMMARY

This paper is a discussion of the operation of mercantile exchanges and the services they provide for the marketing of poultry and eggs in the United States, with emphasis on futures trading in eggs. In the spring when egg production is heavy, from 6,000,000 to 8,000,000 cases are stored for consumption during the following fall and winter. The speculative risk involved can be avoided by the merchant who uses the hedging facilities available through trading in futures. To describe the process of hedging, the steps taken by a merchant to protect himself against the hazards of price fluctuations are specifically shown.

TRENDS IN INTERNATIONAL TRADE IN POULTRY AND EGGS

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The poultry industry is an important part of the agricultural economy in practically every country of the world. Generally speaking, however, these industries have been developed on the basis of supplying the requirements within the domestic market. Furthermore, the very nature of the products of the poultry industry has made them less adaptable for transportation over long distances than has been the case with the major staple agricultural commodities entering into world commerce.

Nevertheless, there has developed in recent years a very substantial international trade in poultry and eggs. This trade may be divided into three categories: (1) the trade in eggs in the shell, (2) the trade in egg products and (3) the trade in dressed poultry. (The only international trade in live poultry of any importance is that between the United States and Canada.) The principal exporters of eggs in the shell at the present time are Denmark and the Netherlands. China dominates world export trade in egg products. Hungary, Irish Free State, and Bulgaria are the leading exporters in recent years of dressed poultry.

On the import side by far the most important markets for eggs in the shell have been the United Kingdom and Germany; these countries and the United States have been the largest markets for egg products. The principal importers of dressed poultry are the United Kingdom, Germany, and Switzerland.

INTERNATIONAL TRADE IN EGGS IN THE SHELL

Eggs in the shell represent much the most important segment of international trade in poultry and eggs. First of all, it may be noted that the great bulk of the world's trade in shell eggs is carried on among the European countries. An outstanding feature of this European trade has been the shift in the business from exporting countries in eastern Europe to exporting countries in western Europe. For instance, comparing the trade in 1936 with that of the years 1909 to 1913, the exports of the eastern and southeastern European countries, principally what are now Russia, Poland, Hungary, Bulgaria, Rumania, and Yugoslavia, show a decline of more than two-thirds. Before the war Russia was an important exporter of eggs but its exports have been of negligible importance in recent years.

On the other hand, during the same period the egg export trade of the Scandinavian countries, the Netherlands, and Belgium show an increase of nearly sixfold. The largest increases in the export trade have been made by Denmark and the Netherlands. In the case of the former the increase was from an average of 36,000,000 dozen during the 5-year period 1909-13 to 134,000,000 dozen in 1937. This latter figure was, in turn, almost double the average annual exports during the period 1925 to 1929. With regard to the Netherlands, the increase from prewar to 1937 was from 29,000,000 dozen to 112,000,000 dozen.

The principal factors involved in this shift in the European export trade in shell eggs are to be found, first, in the virtual disappearance of Russia as an egg exporter and, second, in the development of the poultry industry of certain western European countries on a highly efficient and scientific basis. In the eastern European countries, whence most of the European egg exports formerly came, poultry raising is more or less a side line in general farming.

The European egg importing countries are much fewer than the exporting countries. Two countries, the United Kingdom and Germany, have in the past accounted for more than two-thirds of the world imports of eggs. Relatively minor European importing countries have been Switzerland, Spain, Italy, and Czechoslovakia.

There has been a sharp drop in world imports of shell eggs since 1930. In that year approximately 654,000,000 dozen eggs were imported, while in 1937 world imports amounted to only 439,000,000 dozen. This is a reduction of about one-third. The principal factor in this decline in the world import trade in eggs is the reduction in imports into Germany, from 220,000,000 dozen in 1930 to 132,000,000 dozen in 1937. It does not appear from available information on German egg consumption that this considerable decline in imports has been compensated for by increased domestic production of eggs. In other words, German egg consumption has declined in recent years by approximately the same amount as the decline in imports. It should be noted, however, that German imports in 1937, at 132,000,000 dozen, were substantially above the record low imports in 1935 of only 92,000,000 dozen.

The egg imports of the United Kingdom, the world's largest importer, showed a considerable decline from 264,000,000 dozen in 1930 to only 184,000,000 dozen in 1933 but have since recovered to 247,000,000 dozen in 1937, a larger amount than was imported on the average during the 1920's.

Spain has been the third largest egg importing country. Figures are not available showing imports into Spain during 1936 and 1937. It is of interest, however, to note that prior to 1936 egg imports had been running substantially larger (about 50,000,000 dozen annually), than they were in the 1920's when imports averaged about 35,000,000 dozen annually.

Switzerland is the only other important importer of eggs in Europe and its imports have been running slightly larger (in the neighborhood of 20,000,000 dozen a year), than during the 1920's.

Outside of Europe, China is the leading egg exporting country. China's exports of eggs in the shell in recent years have been around 33,000,000 dozen annually against average exports during the period 1925–29 of 50,000,000 dozen. The principal markets for Chinese eggs have been Japan, Hong Kong, and a few other Asiatic centers.

During the 1920's the United States was, next to China, the leading non-European egg exporting country. These exports went primarily to four countries—Canada, Mexico, Cuba, and Argentina. In recent years egg exports from the United States have been negligible, chiefly because of greatly increased restrictions on imports and large domestic production in the countries that were formerly important markets.

At the present time the most important non-European importer of eggs in the shell is British Malaya. Formerly Argentina, Cuba, and Mexico were of some importance in this respect but imports into these countries in recent years have been very small.

INTERNATIONAL TRADE IN EGG PRODUCTS

International trade in egg products has shown a phenomenal rise since the years immediately preceding the World War. In 1937, for instance, the quantity of egg products, such as dried and frozen whole eggs, albumen, and yolks, entering world trade channels was about seven times as large as the average during the period 1909–13.

The total volume of international trade in egg products sustained a sharp decline during depression years. According to data compiled by the International Institute of Agriculture, the average annual export volume of egg products during the period 1927 to 1931 was 152,000,000 pounds. By 1933 this quantity had been reduced to 106,000,000 pounds. But improved business conditions in 1937 brought a sharp rise in this trade and the estimated total volume entering into world commerce in that year was 165,000,000 pounds.

China accounts for about 85 percent of the total volume of egg products moving in international trade channels. Most of the remainder originates in Hungary.

A review of the distribution of these exports shows that Great Britain is not only the largest importer of egg products but, with the exception of 1933, has been increasing its imports. Thus, from a yearly average of 66,000,000 pounds in the period 1925 to 1929, imports into Great Britain increased to 97,000,000 pounds in 1937. In the latter year British imports of egg products accounted for about two-thirds of the total volume moving in international trade.

Germany is the second largest importer of egg products. German imports reached their peak of 27,000,000 pounds in 1930. After that year German imports declined to a low of 11,000,000 pounds in 1933 but have since risen substantially, reaching 24,000,000 pounds in 1937.

The United States, the Netherlands, and France are other important markets for egg products, although in recent years the volume of their imports has been curtailed considerably in comparison with predepression levels.

INTERNATIONAL TRADE IN DRESSED POULTRY

The great bulk of international trade in dressed poultry, probably as much as 90 percent, is concentrated in Europe. The American countries account for most of the remainder.

In 1937 the total European export trade in dressed poultry, amounting to approximately 112,000,000 pounds, was 12 percent larger than the average exports during the period 1925 to 1929. On the other hand, a comparison of the 1937 volume with that of the peak year 1931 reveals a decline of 20 percent. Four countries—Hungary, Bulgaria, Rumania, and the Irish Free State—accounted for 83 percent of total European exports of dressed poultry. Hungary alone, with 51,000,000 pounds, accounted for 45 percent of the total in 1937. Hungarian exports in that year were more than the average exports during 1925 to 1929. Prior to 1930 Russia was the principal exporter of dressed poultry, the export volume of that country reaching a high of 42,000,000 pounds in 1929. In 1937 the volume of Russian exports amounted to only 4,000,000 pounds.

The import trade in dressed poultry is concentrated in even fewer countries than is the case in the export trade. For example, in 1937 Great Britain and Germany took almost three-fourths of the total imports entering into the channels of European trade. Austria, Switzerland, and Italy took most of the remainder. Imports of dressed poultry into the United Kingdom increased steadily in postwar years to a peak of 73,000,00 pounds in 1931. These imports declined greatly during the depression but rose to 55,000,000 pounds in 1937. Unlike the situation with respect to shell eggs, German imports of dressed poultry have been substantially larger in recent years than in the predepression period.

Outside of Europe, the principal trade in dressed poultry consists of an exchange between the United States and Canada. In recent years this trade has been predominantly from Canada to the United States. The other principal movement of dressed poultry in the Western Hemisphere consists of the importation into the United States of dressed turkeys from Argentina.

FOREIGN TRADE OF THE UNITED STATES IN POULTRY AND EGGS

The foreign trade of the United States in poultry and eggs has never been of significance in relation to American production. This is indicated by the fact that the total value of United States foreign trade in eggs and poultry is less than 1 percent of the total cash income derived by American producers of eggs and poultry.

Such foreign trade as the United States has had in these products has chiefly consisted, on the one hand, of exports of eggs in the shell and, on the other hand, imports of egg products and live poultry. Shell egg exports from the United States reached their peak in 1928 at 38,000,000 dozen. These exports declined to an annual average of 2,500,000 dozen in 1932 to 1937. Details by countries are shown in tables 1 and 2.

As previously indicated, the decline in United States exports of shell eggs may be attributed largely to increased import restrictions in foreign markets. In the Latin American countries, to which the United States formerly exported substantial quantities of shell eggs, there has been in recent years a marked increase in home production.

On the import side egg products from China have always played an important role. But these imports, which averaged 21,000,000 pounds during the period 1925 to 1929, fell to an average of only 4,500,000 pounds during the period 1931 to 1934, due, in part, to an increase in the United States duty on egg products and, in part, to depressed economic conditions. With an improvement in economic conditions in this country in 1937 imports of egg products rose to a little over 10,000,000 pounds. In 1938, however, imports were the lowest for many years, partly as a result of disturbed political conditions in China and partly because of less favorable economic conditions in the United States, as compared with the preceding year. It is of interest to note that, even when United States imports of Chinese egg products were at a peak in the late 1920's they never comprised, in terms of the equivalent shell eggs, more than 2 percent of the total egg consumption of the United States.

United States exports of dressed poultry have never been large. In recent years these exports, mostly to Panama and the United Kingdom, have been about 2,000,000 pounds annually. But while exports have been small, imports of dressed poultry have been smaller. The peak in imports to date was reached in 1928-29, when a total of almost 6,000,000 pounds of dressed poultry was brought into the United States from abroad. In 1937 imports of dressed poultry into the United States amounted to 1,500,000 pounds, of which turkeys from Argentina comprised 12 percent,

TABLE 1.—*Poultry, dressed: Exports and imports of specified countries, average 1925–29, and annual 1930–37*

Principal exporting countries	Exports								
	Average 1925-1929	1930	1931[1]	1932	1933	1934	1935	1936	1937[2]
	1,000 pounds	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*	*1,000 pounds*
Soviet Union	26,762	35,494	38,358	22,177	11,034	5,593	4,585	2,725	4,061
Hungary	24,342	36,686	40,877	29,081	41,996	52,463	49,774	39,653	51,423
Irish Free State	12,095	13,622	12,272	11,404	11,768	15,287	11,697	11,675	11,619
Czechoslovakia	3,420	2,003	531	42	35	29	14	829	972
Rumania	2,765	7,385	11,585	12,368	9,532	11,805	11,286	9,677	....
Bulgaria	433	1,923	4,012	4,955	4,165	6,467	8,186	9,624	11,872
Poland	1,087	1,323	1,900	....	....	3,512	2,478	4,708	4,048
Netherlands	5,777	8,558	8,004	6,244	7,905	5,490	4,214	3,779	4,731
France	13,887	14,743	7,943	4,285	3,370	1,782	1,919	1,965	1,911
Belgium	2,651	4,376	6,808	2,524	2,077	1,099	....	832	987
Italy	4,074	3,348	3,592	2,674	1,331	1,134	653	576	481
Finland	701	756	1,155	1,307	1,446	1,537	1,243	1,586	1,646
Denmark	15	14	44	779	2,374	4,885	5,246	6,324	7,109
China	760	263	1,720	(3)	1,081	1,007	1,030	1,101	1,543
Others	1,953	2,092	2,421	1,796	1,579	1,596	1,097	1,042	882
Total	100,308	132,586	141,222	99,636	99,693	113,686	103,422	96,096	103,285
Principal importing countries	**Imports**								
United Kingdom	50,880	62,127	72,935	56,278	55,489	50,281	46,845	46,591	55,193
Germany	27,664	42,127	30,858	31,029	30,609	45,164	....	46,008	43,048
Austria	14,089	22,370	22,916	19,245	17,269	15,351	16,818	14,411	14,834
Switzerland	7,223	8,569	9,138	9,124	8,720	7,900	7,362	7,994	8,788
Italy	1,277	3,535	6,398	9,040	5,192	6,508	7,333	3,636	4,797
France	3,566	8,902	15,196	5,225	3,497	2,160	1,436	1,011	1,400
Others	2,443	3,155	2,795	1,691	1,086	536	780	5,047	4,987
Total	107,142	150,785	160,236	131,632	121,862	127,900	[4]80,574	124,698	133,047

Bureau of Agricultural Economics. Compiled from official sources.

[1] Six months January-June. [2] Preliminary. [3] Includes game. [4] Germany not included.

TABLE 2.—*Eggs in the shell: International trade, average 1925-29, annual 1930-37*

Principal exporting countries	Exports								
	Average 1925-29	1930	1931	1932	1933[1]	1934	1935	1936	1937[1]
	1,000 dozen	*1,000 dozen*	*1,000 dozen*	*1,000 dozen*	*1,000 dozen*	*1,000 dozen*	*1,000 dozen*	*1,000 dozen*	*1,000 dozen*
Netherlands	98,429	124,859	126,689	117,667	83,740	94,509	90,833	95,146	[2]111,933
Soviet Union	86,978	14,471	30,038	10,554	2,895	1,771	13	147	317
Poland	76,215	80,999	70,687	54,971	34,547	31,201	33,734	35,446	38,771
Denmark	67,641	71,852	81,193	92,059	89,195	93,798	97,688	116,813	134,409
China	56,278	51,360	50,944	[3]29,657	29,555	26,629	24,899	33,067	33,503
Irish Free State	47,058	47,355	46,097	38,831	34,694	34,680	30,548	29,669	24,588
Belgium	41,430	42,926	47,778	51,860	27,569	19,854	15,477	16,575	17,516
Italy	25,943	13,701	13,205	5,692	1,464	1,048	380	58	348
France	24,536	23,512	7,854	1,199	427	1,666	1,840	1,629	567
United States	22,521	18,579	7,684	2,319	1,866	1,928	1,812	2,098	2,376
Hungary	18,049	19,370	17,612	9,403	16,927	13,973	12,135	10,191	16,847
Bulgaria	17,258	28,239	32,876	27,637	23,031	21,361	18,775	25,706	25,744
Rumania	15,011	24,725	19,008	23,232	11,997	10,814	10,141	17,650	[2]15,151
Morocco	14,985	14,629	13,828	13,773	14,926	15,353	17,119	15,802	[2]14,530
Egypt	10,879	8,202	10,445	16,986	14,235	9,618	4,846	6,323	4,837
Algeria	5,830	4,233	1,898	1,233	1,346	1,431	1,989	4,511	4,248
Lithuania	5,313	4,599	5,083	3,816	2,400	1,604	2,292	5,599	6,422
Sweden	4,422	6,543	4,289	6,477	4,372	4,559	4,402	3,746	5,921
Union of South Africa	3,477	6,158	6,143	5,458	4,711	3,221	3,792	3,966	2,870
Finland	58	636	2,771	9,211	14,662	14,629	12,831	11,391	13,120
Turkey	....	....	....	....	26,324	15,341	8,944	8,486	[2]4,458
Others	1,998	3,121	3,350	4,570	4,588	4,565	5,123	5,596	5,368
Total	644,309	610,069	599,472	526,605	445,471	423,561	399,613	449,615	483,844
Principal importing countries	**Imports**								
United Kingdom	238,350	264,306	258,729	199,332	183,739	187,167	197,186	244,622	247,316
Germany	220,035	219,909	193,915	197,037	120,958	109,362	92,123	101,897	131,828
Spain	34,479	39,154	33,370	34,218	55,706	50,758	49,129	....	....
Austria	22,033	25,869	25,617	16,797	13,181	9,817	6,709	5,463	7,510
Italy	17,969	33,543	36,213	51,425	12,908	12,123	7,416	3,288	12,362
Japan	20,465	8,167	12,142	161	44	2	....	80	....
Switzerland	17,132	20,221	23,003	24,752	22,016	21,968	20,558	20,035	20,716
Argentina	9,791	14,846	8,318	1,004	376	285	48	8	1,690
Cuba	8,793	1,314	55	5	....	....	....	....	....
Philippine Islands	5,935	6,958	10,990	9,899	3,841	1,909	1,593	1,956	[2]1,970
Czechoslovakia	4,917	7,936	12,136	11,894	6,932	5,874	8,050	8,898	8,940
Mexico	4,202	4,349	87	24	17	11	[2]22	[2]35	....
British Malaya	3,638	4,341	3,366	1,588	1,896	3,099	3,377	4,648	6,559
Canada	2,244	2,908	68	40	25	30	27	119	37
Total	609,983	653,821	618,009	548,176	421,639	402,405	386,238	391,049	438,928

Bureau of Agricultural Economics. Official sources except where otherwise noted. In countries reporting other than dozens of eggs, the conversion factor used is $1\frac{1}{2}$ pounds equals 1 dozen.

[1] Preliminary.

[2] International Yearbook of Agricultural Statistics.

[3] Does not include Manchuria after June 30, 1932.

with the remainder comprising chiefly dressed chickens coming mainly from Canada.

EFFECT OF TRADE AGREEMENTS ON UNITED STATES FOREIGN TRADE IN POULTRY AND EGGS

Canada is the only country with which the United States has concluded a trade agreement in which poultry and eggs are significantly involved. In the first trade agreement with that country, effective January 1, 1936, the United States duty on live poultry from Canada was reduced from 8 to 4 cents per pound and that on dressed chickens and guineas from 10 to 6 cents. At the same time Canada reduced its duty on live and dressed poultry from 20 to $17\frac{1}{2}$ percent ad valorem. Subsequent to the conclusion of the trade agreement, the United States imports of Canadian live poultry rose from 42,000 pounds in 1935 to 4,441,000 pounds in 1937. That these imports were due only partly to reduced duty is indicated by the fact that they did not continue at the high level of 1937 during 1938. In fact, imports of poultry from Canada in the first 9 months of the latter year amounted to only 652,000 pounds against 2,433,000 pounds during the corresponding period in 1937.

In the second trade agreement with Canada, effective January 1, 1939, the United States rates of 6 cents a pound on dressed chickens and guineas and 4 cents on live chickens, turkeys, geese, ducks, and guineas were continued. A reduction was made, however, in the United States duty on dressed ducks and geese from 10 cents per pound to 6 cents. On the other hand, Canada further reduced its duty on dressed and live poultry to 15 percent ad valorem, compared with 17½ percent in the earlier agreement. But there was another change of interest to the American poultry industry in the reduction in the Canadian duty on baby chicks from 20 percent ad valorem, equivalent to about 6 cents each, to a specific rate of 4 cents each.

The principal duty change in the second trade agreement with Canada applies to eggs in the shell. In this agreement the United States reduced its import duty on shell eggs from 10 to 5 cents a dozen. Canada made the same reduction in its duty on eggs in the shell.

There is a reciprocal trade in shell eggs between the United States and Canada with the movement from the United States to Canada usually larger than the movement in the opposite direction. The great bulk of both the United States and Canadian trade in shell eggs is confined to trade with each other.

These changes in import duties of the United States and Canada affecting poultry and eggs are calculated to increase substantially the interchange between the two countries in these products. It is not likely, however, that their trade with other countries will be significantly affected. In the case of the United States, for instance, the only other products of the poultry industry imported in significant quantities are dressed turkeys from Argentina and dried and frozen eggs from China. The duties on these products have not been changed under the trade agreements program.

The main significance of this program to the poultry industry of the United States, however, does not concern any specific concessions made by the United States or secured by the United States in particular trade agreements. It is extremely doubtful whether the maximum cut permitted under the Trade Agreements Act of 50 percent in the United States duties on all poultry and egg items would lead to imports that would represent more than a very small, practically negligible, fraction of American production. On the other hand, concessions secured from foreign countries in their restrictions on imports of American poultry and eggs cannot be expected to lead to a volume of exports that would represent an appreciable proportion of American production.

In other words, the American poultry industry must continue to rely on the domestic market in the future, as it has in the past. Because their commodities are costly to transport and because their production can be adapted to most parts of the world, United States poultry and egg producers can sell only about as much of their products as are consumed in the United States; and, no matter what happens to the import duties, they will supply practically all of the eggs and poultry consumed in the United States. The poultry producers' income from sales in the domestic market will depend primarily upon the level of economic conditions in the United States.

The real significance of the trade agreements program to the American poultry producer, therefore, lies in its effect on general economic conditions and the level of consumption in the United States. The basic purpose of the program is to increase the real level of consumption of the American people through an expansion of international trade. Hence it is quite accurate to say that the trade agreements program is being directed toward an objective which is of most vital concern to the American poultry and egg producer.

SUMMARY

In recent years a very substantial international trade in poultry and eggs has developed which consists chiefly of trade in (1) eggs in the shell (2) egg products and (3) dressed poultry. Denmark and the Netherlands are the principal exporters of eggs in the shell; China dominates world exports in egg products; Hungary, Irish Free State, and Bulgaria are the leading exporters of dressed poultry.

The total value of United States foreign trade in eggs and poultry is less than 1 percent of the total cash income derived by American producers of eggs and poultry. Although imports of egg products from China are important, it is of interest to note that, even at their peak, they never comprised more than 2 percent of the total egg consumption of the United States. United States exports of dressed poultry, mostly to Panama and the United Kingdom, average only 2,000,000 pounds annually. Imports of dressed poultry into the United States are of even smaller volume.

Canada is the only country with which the United States has concluded a trade agreement in which poultry and eggs are significantly involved. Import duties were reduced by both countries in this agreement for the purpose of substantially increasing the interchange between these two countries. It is doubtful whether these changes will increase United States trade with Canada by more than negligible amounts when compared with total production. The poultry industry, as in the past, will have to rely mostly on home markets. The real significance of the trade agreement program to the American poultry producer, therefore, lies in its effect on general economic conditions and the level of consumption in the United States.

ECONOMIC SERVICES PROVIDED THE POULTRY AND EGG INDUSTRY BY GOVERNMENT AND PRIVATE AGENCIES

By JAMES R. HAWKINSON, *Professor of Marketing and Assistant Dean, Northwestern University School of Commerce, Evanston, Illinois, U. S. A.*

You have already heard something of the magnitude of the poultry industry in the United States. Most of you are also aware of its extremely seasonal characteristics. Figures show that egg production per farm flock on the average is between three and four times as great in April as in December. The size of the laying flock itself is, on the average, about 30 percent greater in January than in September. The number of eggs sold by producers is much greater in spring and early summer than in the fall, accounting for an egg storage industry with peak stocks about August 1, composed of frozen egg meats and eggs in the shell. The seasonal variation in size of these stocks is very great. Poultry, on the other hand, although marketed during all months of the year, is sold in largest volume in the fall and early winter when young stock from the current year's hatch and turkeys are sold. The seasonal peak in storage stocks of poultry is usually reached in January, although each class has its own seasonal characteristics.

In addition to the pronounced seasonality in production, selling, and storage, there are significant changes from year to year. The number of chickens on farms on January 1, 1931 was estimated to be about 16 percent greater than on January 1, 1938. The estimated annual production of chickens in 1930 was 22 percent greater than in 1937. Similarly, egg production at its recorded peak in 1930 was estimated as 17 percent greater than at its low point in 1935. The volumes of eggs and poultry marketed also show great yearly variations, with stocks of shell eggs in cold storage on August 1, 1933 reported as 48 percent greater than those on the same date in 1932.

Any industry needs economic information as a basis for efficient production and marketing. An industry supplying staple food products, such as eggs and poultry, and constituting an important part in the national farm income and in the consumer's cost of living, is particularly in need of such information. The magnitude of seasonal and yearly changes noted above emphasizes the need for adequate economic services. The large fluctuations in production alone point to problems which need study. Why should supplies vary so much? Is such variation necessary? Would there be a greater degree of stability if the causes were known? Such questions form proper subjects for research, but research itself demands accurate economic information.

For the most part this paper is limited to an evaluation of statistical and research services and a consideration of the problems incident to furnishing those services. There are many other agencies whose work is important, although perhaps not strictly economic in character.

GOVERNMENT AGENCIES AND THEIR SERVICES[1]

The United States Government, chiefly through the Department of Agriculture, is the most important source of economic services for the poultry industry. The economic services of the Bureau of Agricultural Economics are divided roughly into two groups. The first is the market news service, the object of which is to secure and publish important market information on supplies and prices, on the movement of poultry to the market, on the stocks held by dealers and in cold storage, and on the rate of movement of these stocks into or out of storage. In addition to the regular daily reports from the important markets, other periodical reports are issued, including:

1. Weekly purchases of poultry and eggs by country packers.
2. Monthly export and import report.
3. Monthly live poultry report.
4. Monthly egg and poultry market review.
5. Monthly hatchery report.
6. Monthly origin of receipts, by States.
7. Monthly egg and poultry situation.
8. Monthly cold storage report.
9. Monthly poultry and egg production report.
10. Annual production estimates, by States.
11. Annual outlook report.

The second important type of economic information is market research, which is of two kinds. The first, market analysis, studies practices, facilities, and consumer preference and demand at given points of time for the purpose of evaluating and improving production and marketing methods. The second type of research, analysis of marketing problems over a period of years, is designed to be useful to farmers and dealers in planning production. This last type of research is best typified by the data in the monthly situation and the annual outlook reports.

In the Poultry Section of the Agricultural Adjustment Administration a new type of activity has been developed, looking toward greater stability through the medium of marketing agreements. In cooperation with the Federal Surplus Commodities Corporation, surplus products are purchased and withdrawn from the market for relief distribution. In connection with these two types of activities, studies on production and prices of both poultry and eggs have been made.

The Commodity Exchange Administration

[1] Since this paper was written, there have been some reallocations of functions among the Government agencies.

supervises future trading in eggs on contract markets.

The Bureau of Animal Industry conducts research in the problems of poultry and egg production to secure information for producers about profitable types of poultry and control of loss through flock management practices. The Packers and Stockyards Administration seeks to "free interstate commerce from burdens and restraints and protect producers and consumers against unfair, deceptive and fraudulent practices and devices in connection with the handling of live poultry. The law requires that all persons handling live poultry in interstate commerce or furnishing services or facilities in connection with live poultry at cities or markets designated by the Secretary shall have a license issued by the Secretary."[2]

The Bureau of Entomology and Plant Quarantine develops methods for controlling insect parasites.

The Bureau of Chemistry and Soils studies problems related to egg drying, egg processing, and the influence of micro-organisms on the keeping quality of egg and poultry products. It also studies the effect of processes and practices in marketing on quality and condition of egg and poultry products.

The Bureau of Home Economics studies the various egg and poultry commodities as food products, together with the effects of marketing methods on palatability and consumer acceptance.

The Food and Drug Administration, through its authority over shipments in interstate commerce, controls the sale of products which are unfit for human consumption.

The Cooperative Extension Service of the Department of Agriculture, working with the State and county extension services, carries information on research and marketing to the producers.

The Office of Information issues news releases and publications of popular and scientific character dealing with production and marketing of poultry and eggs.

The Office of the Experiment Stations administers the Federal-grant funds spent by the State agricultural experiment stations in research work.

The Farm Credit Administration also has an important economic influence on the poultry industry through its extension of loans and its research for farmers' cooperative marketing organizations.

The United States Department of Commerce collects and publishes figures on imports and exports, and through the Bureau of the Census makes enumerations of poultry numbers and egg production on farms once every five years.

The United States Department of Labor records average wholesale and retail prices and index numbers for poultry and eggs and makes cost of living studies, some of which are in cooperation with the Bureau of Home Economics of the Department of Agriculture.

The International Institute of Agriculture in Rome furnishes information on poultry and egg production in foreign countries.

The various States, through their administrative agencies and State colleges, make many important studies and furnish information on a wide range of subjects dealing with different phases of production and marketing of poultry and eggs. Many of these projects are carried out in cooperation with the United States Department of Agriculture.

PRIVATE AGENCIES AND THEIR SERVICES

In addition to the Government, there are a number of private agencies whose services are indispensable to the poultry industry. The National Poultry, Butter, and Egg Association, among its many services, renders a very important one in connection with its efforts to secure improved transportation facilities and just and equitable transportation rates and charges for poultry and eggs in the United States.

Important media through which economic information is widely disseminated are the commercial news dispatches of the telegraph companies. These dispatches are provided on subscription and delivered regularly by the companies who gather the information from exchanges, commercial reporting agencies, and Government offices, and distribute it each day to their subscribers.

No discussion of economic services performed for the poultry industry would be complete without mention of the activities of the Urner-Barry Publishing Company of New York City. This organization has had an important influence on the industry for many years. Probably the most important publication of this agency is the Producers' Price Current, which includes daily information on prices and receipts of poultry and eggs in their various grades and classes in New York and Chicago. Another service of the Urner-Barry Company is the weekly publication of the American Creamery and Poultry Produce Review which includes daily, weekly, and monthly summaries of economic information.

Similar services for Chicago are performed by the Chicago Produce Publishing Company, which publishes a daily Price Current, including price information for Chicago on poultry and eggs and supply information on eggs for the four large markets. In addition, the Dairy Produce Publishers, Inc., through the medium of its publication "Dairy Produce" and its yearbook, makes monthly and annual summaries of current economic information.

The Chicago Live Poultry Board, an organization composed of wholesale poultry dealers in Chicago, meets from 9:00 a.m. to 9:30 a.m. each week day and trades in both live and dressed

[2] *Poultry Activities*, December 1937 (United States Department of Agriculture).

poultry in order to crystallize market opinion and arrive at price quotations to be used as a basis for the day's business.

The Mercantile Exchanges in several of the larger markets, but particularly in New York and Chicago, operate both a daily spot call where member dealers trade in eggs and a contract market where members deal in contracts for future deliveries. Those at New York and Chicago, located in the two largest cities in the country, are in a strategic position to keep traders posted on current information. Many statistical reports are issued by these exchanges, based partly on information gathered from Government agencies and partly on information developed as a result of trading activities under their own direction. These exchanges also furnish inspection services for eggs sold in carlots or delivered under their rules, and their certificates are frequently used as a basis for trading by the dealers located at points so distant from each other as to make actual inspection of the product impossible.

The Institute of American Poultry Industries represents wide interests in the poultry and egg industry. In a recent bulletin, the Institute states that its activities "look toward better control of the product, a better informed industry, and the utmost service to consumers and flock owners."[3] With the country divided into regional groups, there is cooperation among operators of poultry and egg processing plants, looking to a solution of the problem of quality buying by shippers, processors, and packers. Cooperation is also encouraged with State agricultural colleges and State marketing officials in the development of buying grades for poultry and eggs. In addition to its other activities, research is promoted and the results disseminated through the annual Fact Finding Conference, in which many college poultrymen take part. Also, the National Advisory Committee on Research was created in 1932 and is an industry service sponsored by the Institute.

The Poultry Science Association is composed of instructors and investigators in the United States and Canada. Its constitution states that its object is: "the advancement of poultry husbandry throughout the United States and Canada, especially as it relates to the profession of teaching and research."[4]

The American Poultry Association

is a national organization of all branches of the poultry industry, to develop the business in all its phases; to revise standards for poultry; to encourage the breeding of standard poultry; to promote the holding of shows; to encourage the highest standards of business ethics of the poultry business; to encourage Government and State experimental work with standard-bred poultry; and to promote legislation beneficial to the poultry industry; to disseminate accurate and reliable information among consumers and producers relative to the value of poultry and eggs in their proper use as foods; to secure to its members improved transportation and storage facilities for poultry and its products and just and equitable rates and charges for the same; to encourage surveys of poultry resources and to collect statistics which shall be classified and distributed with other data bearing upon the welfare of the business and to see that provision is made by National Census Bureaus to include the entire poultry industry with proper classification; to help secure uniform interchangeable standards for poultry and its products in all markets; to foster and promote the passage of such laws as will insure the economical production of the largest practical volume of standard-bred poultry and eggs; to direct special attention to the desirability of poultry and eggs in our dietary and to the superior value of standard-bred poultry for general purposes.[5]

The International Baby Chick Association has as its object "to foster, promote, and improve and protect the Baby Chick Industry and All Allied Branches of Poultry Husbandry."[5]

Important regional associations interested mainly in the problems of their section of the country are: The Pacific States Butter, Egg, Cheese and Poultry Association; the Northeastern Poultry Producers Council; and the Southern Poultry and Egg Shippers Association.

The National Association of Marketing Officials is an agency including Federal, State, and local members concerned with marketing problems and especially the laws affecting the purchase and sale of farm products.

The American Farm Economics Association, whose membership includes economists interested in farm problems generally, is concerned with the economic problems of poultry and egg producers, dealers, and consumers.

This list of organizations interested in poultry problems is not complete, but a complete list would be far too long to include in this paper. This list is offered as evidence of the diversity of interests and organizations supporting the poultry and egg industry. The line of demarcation between the economic and noneconomic functions of such organizations is difficult to draw. The more important consideration, however, is not a particular function involved, but the fact that for united action on the problems of the industry, coordination of the functions of all of these agencies is necessary.

In addition to the agencies and publications mentioned, many others are doing effective work for the poultry and egg industry. In almost every large terminal market some private publishing agency, exchange, or Government office prepares statistics and provides information from other important markets.

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[3] *Report of Activities*, January 1938 (Institute of American Poultry Industries).

[4] *Poultry Science*, July 1938, Volume XVII, No. 4 (Poultry Science Association).

[5] *The American Creamery and Poultry Produce Review*, 1937.

PROBLEMS NEEDING CONCERTED ACTION

Standardization and grading as an industry service is discussed here, as the existence and use of standards have a direct bearing on statistical services—especially prices. At present, one of the most difficult problems in price reporting is that of relating prices to known standards of quality. The existence and wide application of uniform standards would greatly enhance the value of price information. When standards vary, price quotations for different markets naturally lack comparability except for those relatively few persons who are thoroughly aware of the differences and their significance.

The use of uniform standards could be considerably expanded if the various States had more uniform laws, and if all marketing agencies followed these standards and grades. State egg laws furnish an example of the lack of uniformity: Eleven States have statutory standards for egg size, but no two States have exactly the same standards. Four States provide for three size classifications of eggs and seven provide for four. The specifications of the different classes vary from State to State. The laws of ten States still prescribe egg classifications which are not based on candling, although candling is the commonly accepted method of determining quality and is the basis for the Federal grades.

It has been noted that a great number of agencies supply information to the members of the poultry and egg industry. In fact, one would think that with so many organizations there would be complete data on all phases of production, trading, and consumption. However, the problem of providing an industry with adequate economic information is seriously complicated by changes in economic institutions, in economic thinking, and in marketing practices which come with the passage of time. At one period it was thought sufficient that economic services measure the fluctuations in production, in supply, and in prices. It is important now that we know as nearly as possible the actual amount which is produced because it is important that production be maintained at a level sufficient to supply a normal standard of nutrition for our population, plus or minus the requirements of foreign trade. The course followed by producers and dealers in meeting industry problems also requires research, and the reliability of the conclusions drawn from this research can be only as accurate as the information on which this research is based. The greater emphasis on consumption, for instance, requires more knowledge about the rate at which commodities are taken at different levels of price. This information is largely nonexistent at present, except as it is implied from available data on production and stocks.

Another type of information very much needed and largely lacking deals with the relationship of quality to consumer acceptance. Emphasis has been placed on the importance of quality in increasing consumption and increasing farm incomes. However, very little definite information is available on this subject. If data were available showing the quality proportions of products marketed, this information, together with prices paid by consumers and dealers for different quality classes, would provide a basis for evaluating quality production programs, both with respect to consumer acceptance and farm income.

The development of new processes and techniques within the industry also raises problems which require constant attention. The development of the frozen egg industry in the United States during the postwar years to a point where it now includes between 35 and 40 percent of the eggs in cold storage, is an object in point. Also, at present we seem to be at the beginning of a change from ordinary methods of poultry dressing to the marketing of poultry full-drawn and eviscerated at the country packing plant. Eviscerated poultry is reduced by about 25 percent in weight and, if widely accepted, would make considerable difference in the weights reported as market receipts or the volume held in cold storage as compared with earlier years before evisceration became a general practice. Also, the dressing out of approximately 25 percent of the original weight of poultry for sale would change the price structure, because prices on poultry at eviscerated weights would have to be higher per pound than for undrawn poultry. These ever-changing problems suggest the need for better industry organization which recognizes the necessity of additional economic information and the need for assisting in its development.

Little information is available on the production or stocks of dried eggs at the present time, but it no doubt would be desirable to have such reports. Also beneficial would be more and earlier information concerning the growing turkey crop, the movement to market, market conditions, the rate of consumption, and the percentage of the crop still remaining on farms at the close of each holiday marketing period. Rapid development of the turkey industry during the past decade has brought the problem of additional statistical information distinctly into the foreground.

With recognition of the need for a given type of information, the problems of economical assembly and accurate reporting still remain. These problems face the statistician from the time an economic report is started through its entire continuation. During the hatching season, for instance, a report is published showing changes from the previous year in the number of eggs set by commercial hatcheries and the number of salable chicks hatched. The statistical problems of adequacy and proportionality of this report are very real, and surveys are being made to provide a basis for determining its reliability. Once determined, however, it will be necessary to repeat this survey at intervals in order that shifting trends in production of hatchery chicks may be taken into account.

Another question of similar character is related to estimates of production which must be considered along with market statistics, if the poultry situation at any particular time is to be intelligently analyzed. Estimates of production must be based on samples from commercial as well as farm flocks, since production trends and seasonals for these different types of producers are themselves quite different.

The few responses from the letters sent to the mercantile exchanges throughout the country and other important agencies reiterate the need for more information, as well as for improvement in the accuracy of existing market information. Some practical ideas toward the accomplishment of these ends were offered. A suggestion from Mr. Lloyd S. Tenny, Business Manager of the Chicago Mercantile Exchange, is that the organization set up for the promotion of this Congress be continued on some basis after the Congress is over, probably with strong organizations in each of the States, and that probably later on the industry could take over more directly the organization working toward better quality, better packing, greater consumption, and other strictly industry problems.

Mr. Alexander V. Dye, Director of the Bureau of Foreign and Domestic Commerce, suggests the selection of a committee by private producers and shippers of poultry products to meet with officials of the Bureau at least twice a year to consider problems of mutual interest and to determine the needs of the industry so far as the activities of the Bureau are concerned.

Dr. A. G. Black, writing for the Bureau of Agricultural Economics, says: "Improvements in any service rendered by a governmental agency naturally must have the encouragement and backing of an industry. And it is generally recognized that one of the first needs of the poultry industry is greater coordination and cooperation among the many different poultry organizations. It may be hoped that the work of all branches of the industry in organizing and staging the World's Poultry Congress will provide the necessary stimulus for the coordinated effort. Direct improvement and extension of Federal, State, and private services to the industry would logically follow."

Considerable study of all parts of the industry using the services described is necessary to judge adequately their need and worth. That has been impossible in this paper. A picture of the services available and their sources, together with some critical comments, has been presented for the thoughtful consideration of those who are looking toward the best interests of the poultry and egg industry.

SUMMARY

The many problems in producing and selling poultry products indicate the need for economic services. These have been provided to a great extent by various departments of the United States Government and by private agencies. The Bureau of Agricultural Economics of the United States Department of Agriculture furnishes important market information on supplies and prices, on the movement of poultry to the market, on the stocks held by dealers and in cold storage, and on the rate of movement of these stocks into or out of storage. The Bureau also makes research studies of demand and supply for the purpose of improving production and marketing methods. The States, the National Poultry, Butter, and Egg Association, the publishing companies, especially Urner-Barry Publishing Company and Chicago Produce Publishing Company, and the mercantile exchanges are only a few of the many additional sources of helpful economic services.

To help the industry more adequately, the formulation and wide application of uniform standards are recommended. Additional consumer information is needed, as is also the development of new processes and techniques in production and marketing. It is believed that more useful information and more reliable data would result from closer cooperation and coordination among the many different poultry organizations.

FACTORS AFFECTING PROFITS AND LOSSES ON STORAGE SHELL EGGS

By S. W. Russell *and* G. D. Humphrey, *Commercial Research Department, Swift and Company, Chicago, Illinois, U. S. A.*

There are many factors which it is reasonable to believe affect profits on storage eggs. There are many measures of each factor. Only a few factors are of major importance judging by the experience of former years. All of the other factors have so small an influence on egg prices that they should be neglected entirely when considering the outlook because they are more likely to be misleading than helpful.

This article deals only with factors affecting year-to-year changes. The trend of profits and losses over a period of years, if any, can be observed and allowed for arbitrarily. Hence, from the standpoint of the outlook each year it is unnecessary to consider factors causing gradual changes only.

MEASURES OF PROFITS AND LOSSES IN FORMER YEARS

Profits or losses on storage eggs can be estimated by computing the change from the average price of storage packed Firsts during the period of accumulation, March to June, inclusive, to the average price of refrigerator standards during the period of liquidation, August to December, inclusive, at Chicago, and subtracting the estimated cost of carrying. However, since the cost of carrying does not vary much from year to year, the changes in profits and losses can be studied just as well before allowing for the cost of carrying. Such a computation from 1920 to 1938 inclusive, is shown in table 1 and figure 1.

TABLE 1.—*Change in egg prices from March-June to August-December, at Chicago, 1920-38*

Year	Average price, per dozen		Change
	March-June, inclusive[1]	August-December, inclusive[2]	
	Cents	*Cents*	*Cents*
1920	43.1	52.2	+9.1
1921	26.3	36.5	+10.2
1922	25.2	26.8	+1.6
1923	26.4	27.2	+.8
1924	24.7	36.6	+11.9
1925	30.1	34.1	+4.0
1926	30.2	35.0	+4.8
1927	25.3	31.8	+6.5
1928	30.1	30.9	+.8
1929	29.9	37.5	+7.6
1930	25.3	21.0	−4.3
1931	18.9	18.3	−.6
1932	13.7	23.0	+9.3
1933	14.0	16.3	+2.3
1934	17.0	21.2	+4.2
1935	23.8	22.9	−.9
1936	21.4	27.0	+5.6
1937	22.6	20.1	−2.5
1938	19.9	23.3	+3.4

Compiled from Chicago Journal of Commerce.

[1] Prices of Storage Packed Firsts, weighted by quantity stored each month.

[2] Prices of Refrigerator Standards, weighted by quantity removed from storage each month.

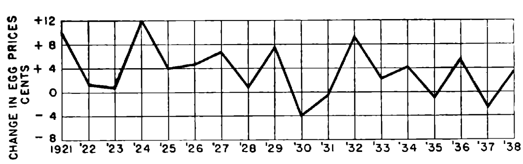

FIGURE 1.—Change in egg prices from spring (March-June) to fall (August-December) 1920-38.

The experience of the last 19 years shows that profits tend to follow losses and losses tend to follow profits in a somewhat regular 2-year cycle. If this tendency were a little more regular there would be no need of studying the factors which have determined it in the past in order to judge the outlook for the future. But since it sometimes is profitable or unprofitable two years in succession, and sometimes is about on a "break-even" basis, it is desirable to study past experience to find bases for judgment on the year ahead.

Judgment alone is not dependable because there are many perfectly reasonable theories which do not work out in practice and some factors which are less important than others. Hence, it is necessary to test the reasonable theories in the light of past experience, discarding those which have evidently not been important in former years and weighting each of the other factors according to the degree to which it was influential in the past.

BASIC DATA USED

Most of the basic data used are compiled currently by the United States Department of Agriculture.

Parts of these data are in the nature of samples; production in 20,000 farm flocks only, price at one market only, and so forth. But our experience with them has convinced us that they are surprisingly adequate samples, at least for the purpose of furnishing explanations of changes in egg prices.

Length of test period

The principal data used in these studies are not available prior to 1925 but tests were made on similar data back to 1920, and in some instances, on prewar experience, with similar results.

Method of analysis

The opinions stated below are based on multiple correlation analyses of a simplified, nonmathematical type, developed to meet this and similar problems during the last 15 years.

A COMBINATION OF FACTORS

The following factors, when combined, furnish a rather complete explanation of changes in egg prices from spring to fall in former years.

1. Proportion stored by August 1.
2. Change in egg production from spring to fall.
3. Change in all food prices from spring to fall.
4. Change in egg prices from spring to fall of the previous year.
5. Average seasonal rise.

The estimated effect on egg prices of each of these factors for each year from 1925 to 1938 inclusive, is shown in table 2. The combined effect of all of them, compared with the actual change in egg prices, is also shown in table 2 and figure 2.

1. Proportion stored by August 1st

The quantity of eggs consumed in the spring is very important, but taken alone is no barometer of the outlook for egg prices. It is the proportion consumed, or stored, that counts. When consumption fails to keep pace with production during the spring, a larger than normal proportion is forced into storage. This condition is usually followed by losses on storage eggs, and conversely (tables 3 and 4 and figure 3).

Apparently "If they won't eat 'em in the spring, they won't eat 'em in the fall," except at lower prices. There have been exceptions to this rule, of course, but nevertheless it works in a large proportion of the years.

TABLE 2.—*Estimated effect of specified factors,[1] singly and in groups, on the change in egg prices from March-June to August-December, 1925-38*

(Prices and changes stated in cents per dozen)

Year	Actual change in prices[2]	Effect of factor—					Factors 1-3-4-5		Factors 1-2-4-5		Factors 1-2-3-5		All 5 factors	
		1	2	3	4	5	Effect	Residual	Effect	Residual	Effect	Residual	Effect	Residual
1925	+4.0	+1.4	+1.5	+1.2	−4.0	+3.6	+2.2	+1.8	+2.5	+1.5	+7.7	−3.7	+3.7	+0.3
1926	+4.8	+2.3	+.6	−1.6	0	+3.6	+4.3	+.5	+6.5	−1.7	+4.9	−.1	+4.9	−.1
1927	+6.5	−.3	+1.4	+.7	−.4	+3.6	+3.6	+2.9	+4.3	+2.2	+5.4	+1.1	+5.0	+1.5
1928	+.8	−.1	+.2	−.3	−1.3	+3.6	+1.9	−1.1	+2.4	−1.6	+3.4	−2.6	+2.1	−1.3
1929	+7.6	+1.7	+.3	−.1	+1.6	+3.6	+6.8	+.8	+7.2	+.4	+5.5	+2.1	+7.1	+.5
1930	−4.3	−2.6	+.7	−3.8	−1.8	+3.6	−4.6	+.3	−.1	−4.2	−2.1	−2.2	−3.9	−.4
1931	−.6	−.3	−1.6	−3.0	+4.2	+3.6	+4.5	−5.1	+5.9	−6.5	−1.3	+.7	+2.9	−3.5
1932	+9.3	+5.8	+.4	−1.4	+2.3	+3.6	+10.3	−1.0	+12.1	−2.8	+8.4	+.9	+10.7	−1.4
1933	+2.3	−1.9	+1.4	+1.7	−2.7	+3.6	+.7	+1.6	+.4	+1.9	+4.8	−2.5	+2.1	+.2
1934	+4.2	−2.8	−.2	+2.2	+.9	+3.6	+3.9	+.3	+1.5	+2.7	+2.8	+1.4	+3.7	+.5
1935	−.9	−.9	−2.6	−.5	−.1	+3.6	+2.1	−3.0	0	−.9	−.4	−.5	−.5	−.4
1936	+5.6	+1.2	−2.0	+.6	+2.5	+3.6	+7.9	−2.3	+5.3	+.3	+3.4	+2.2	+5.9	−.3
1937	−2.5	−3.7	−2.6	−2.0	−.8	+3.6	−2.9	+.4	−3.5	+1.0	−4.7	+2.2	−5.5	+3.0
1938	+3.4	+4.1	−4.3	−1.1	+3.3	+3.6	+9.9	−6.5	+6.7	−3.3	+2.3	+1.1	+5.6	−2.2

[1] The factors are thus described:
1. Proportion stored by August 1, United States total.
2. Proportion of fall to previous spring egg production, United States total.
3. Change in all food prices from March-June to August-December.
4. Change in egg prices from spring to fall, previous year.
5. Average seasonal rise in egg prices.

[2] See table 1.

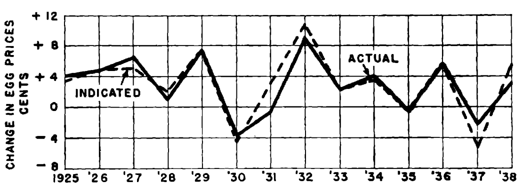

FIGURE 2.—Actual compared with indicated change in egg prices from spring to fall, 1925-38. The indicated changes are based on the five principal factors described in the text. (See also table 2.)

2. Change in egg production from spring to fall

The quantity of eggs produced during the period of liquidation of storage eggs can be estimated as shown in table 5. But here again it is a question of proportion—not "*how many* eggs are going to be produced next October, November, and December?", but "will production be large or small in proportion to production this spring, when the eggs are going into storage?" And even the proportion has seldom been controlling on egg prices; that is, by itself, it has seldom determined whether the year would be one of profits or losses on storage eggs (table 6 and figure 4). However, after allowing for other factors it can be seen that prices are affected somewhat by fall production, (figure 5). But since fall production usually varies by smaller amounts than does storage holdings it has seldom turned a profitable storage year into an unprofitable one, or vice versa. However, the proportion of fall to spring egg production has been very high in recent years, which has had a

TABLE 3.—*Consumption of eggs from March to June, inclusive, in the United States, 1925-38*

Year	Total production[1]	Eggs laid, per farm			Production March-June[3]	Net movement, March-June[4]	Consumption, March-June[5]
		Total for the year[2]	March-June				
			Total[2]	Percentage of total for year			
	Million cases	*Number*	*Number*	*Number*	*Million cases*	*Million cases*	*Million cases*
1926	103.5	307.8	153.8	50.0	51.8	9.7	42.1
1927	107.3	323.7	166.5	51.4	55.2	12.1	43.1
1928	107.4	313.8	157.0	50.0	53.7	11.3	42.4
1929	105.3	311.6	153.7	49.3	51.9	9.8	42.1
1930	108.5	316.2	163.3	51.6	56.0	12.9	43.1
1931	107.0	319.9	156.5	48.9	52.3	10.2	42.1
1932	100.8	303.1	148.5	49.0	49.4	7.0	42.4
1933	98.7	295.1	148.5	50.3	49.6	11.0	38.6
1934	95.6	285.9	142.5	49.9	47.7	11.1	36.6
1935	92.5	279.6	137.7	49.3	45.6	9.5	36.1
1936	94.4	283.5	139.5	49.2	46.4	8.9	37.5
1937	104.6	310.4	149.6	48.2	50.4	12.0	38.4
1938	.....	315.1	148.4	47.0	50.0	7.4	42.6

[1] Reported by the U. S. Department of Agriculture, November, 1938.

[2] Sum of the numbers laid on the first day of each month, as reported by the U. S. Department of Agriculture.

[3] 1925-37 computed. 1938 based on percentage change from previous year in numbers of eggs laid per farm.

[4] Both shell eggs and frozen eggs. Data from U. S. (Dept. of Agriculture).

[5] No allowance is made for number imported, exported, or used for hatching because they would not affect the year-to-year changes in consumption materially.

TABLE 4.—*Proportion of storage holdings of eggs on August 1 to consumption during the months March-June, United States totals, 1925-38*

Year	Storage holdings,[1] August 1	Consumption, March-June	Proportion of holdings to consumption
	Million cases	*Million cases*	*Percent*
1925	11.2	40.1	28.0
1926	11.3	42.1	26.8
1927	13.1	43.1	30.4
1928	12.8	42.4	30.2
1929	11.6	42.1	27.6
1930	14.5	43.2	33.6
1931	12.8	42.1	30.4
1932	9.3	42.4	21.9
1933	12.6	38.6	32.6
1934	12.4	36.6	33.9
1935	11.3	36.1	31.3
1936	10.6	37.5	28.3
1937	13.5	38.4	35.2
1938	10.3	42.6	24.2

Data from U. S. Department of Agriculture.

[1] Shell and frozen, total U. S.

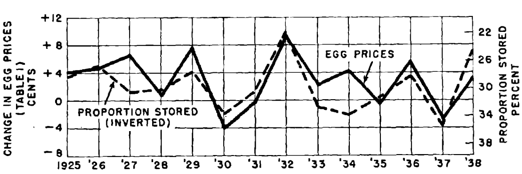

FIGURE 3.—Proportion stored by August 1 compared with changes in egg prices from spring to fall, 1925-38. The "stored" line was turned upside down because this factor affects egg prices adversely.

TABLE 5.—*Production of eggs, October-December, inclusive, United States, 1925-38*

Year	Total production[1]	Eggs laid, per farm: Total for the year[2]	October-December: Total[2]	October-December: Percentage of total for year	Production, October-December[3]
	Million cases	*Number*	*Number*	*Percent*	*Million cases*
1925	97.1	289.5	38.7	13.4	13.0
1926	103.5	307.8	41.8	13.6	14.1
1927	107.3	323.7	43.3	13.4	14.4
1928	107.4	313.8	43.5	13.9	14.9
1929	105.3	311.6	42.3	13.6	14.3
1930	108.5	316.2	44.0	13.9	15.1
1931	107.0	319.9	47.4	14.8	15.8
1932	100.8	303.1	40.9	13.5	13.6
1933	98.7	295.1	38.7	13.1	12.9
1934	95.6	285.9	40.3	14.1	13.5
1935	92.5	279.6	43.5	15.6	14.4
1936	94.4	283.5	42.8	15.1	14.3
1937	104.6	310.4	47.1	15.2	15.9
1938	.....	315.1	50.5	16.1	17.0

[1] From table 3.

[2] Sum of the numbers laid on the first day of each month, as reported by the U. S. Department of Agriculture.

[3] 1925-37 computed. 1938 based on the percentage change from previous year in number of eggs laid per farm.

limiting effect on the rise in egg prices from spring to fall. Increasing fall production should, of course, be offset by decreasing storage holdings in order to keep the supply in balance. If the present trend continues, smaller quantities of storage eggs will be needed before long.

TABLE 6.—*Proportion of fall egg production to production in the previous spring, United States totals, 1925-38*

Year	Production, March-June	Production, October-December	Proportion, October-December to March-June
	Million cases	*Million cases*	*Percent*
1925	50.3	13.0	25.9
1926	51.8	14.1	27.2
1927	55.2	14.4	26.1
1928	53.7	14.9	27.7
1929	51.9	14.3	27.6
1930	56.0	15.1	27.0
1931	52.3	15.8	30.2
1932	49.4	13.6	27.5
1933	49.6	12.9	26.0
1934	47.7	13.5	28.3
1935	45.6	14.4	31.6
1936	46.4	14.3	30.8
1937	50.4	15.9	31.6
1938	50.0	17.0	34.0

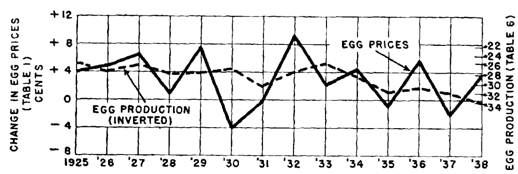

FIGURE 4.—Proportion of fall to previous sprin egg production compared with change in egg prices from spring to fall, 1925-38. The percentage scale is inverted because this factor affects egg prices adversely.

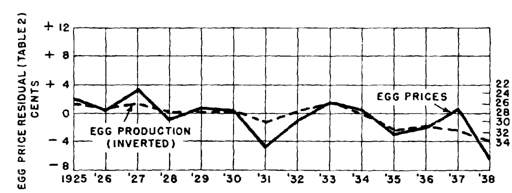

FIGURE 5.—Proportion of fall to previous spring egg production compared with change in egg prices from spring to fall after allowing for the other principal factors (Factors 1, 3, 4, and 5) 1925-38.

3. Change in all food prices from spring to fall

Changes in the average price of all food are not controlling on the changes in egg prices (table 7 and figure 6). However, egg prices do respond somewhat to the influences which cause changes in the average price of all food. This becomes apparent after allowing for the estimated effect of the other factors on egg prices (table 2 and figure 7).

4. Change in egg prices from spring to fall of the previous year

When egg prices rise by less than the usual amount from spring to fall they are likely to rise by more than the seasonal amount the following fall (table 1 and figure 8).

TABLE 7.—*Changes in index numbers of prices of all foods and in factory payrolls, from March-June to August-December, 1920-38*

Year	All foods, prices	Factory payrolls
	Points	*Points*
1920	−17.3	−10.4
1921	+1.1	−5.4
1922	+6.6	+12.8
1923	+1.0	−1.2
1924	+8.0	−5.4
1925	+5.3	+2.0
1926	−.1	+.2
1927	+4.3	−3.6
1928	+2.5	+3.8
1929	+2.9	−3.8
1930	−4.5	−15.7
1931	−2.9	−11.9
1932	+.2	−5.1
1933	+6.3	+15.7
1934	+7.4	−4.8
1935	+2.1	+5.2
1936	+4.1	+9.2
1937	−.9	−9.1
1938	+.9	+8.3

Compiled from index number series of the U. S. Department of Labor.

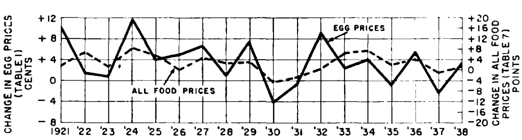

FIGURE 6.—Change in the index numbers of prices of all foods from spring to fall compared with change in egg prices from spring to fall, 1921 to 1938.

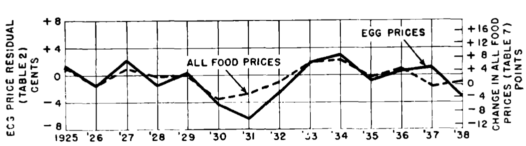

FIGURE 7.—Change in the index numbers of prices of all foods from spring to fall compared with change in egg prices from spring to fall after allowing for the other principal factors (Factors 1, 2, 4, and 5) 1925-38.

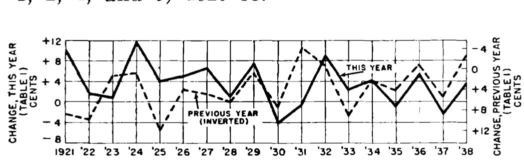

FIGURE 8.—Change in egg prices from spring to fall in the previous year compared with change in egg prices from spring to fall, 1921-38.

This, we believe, is due to the tendency for the trade to overvalue eggs following years of rising prices and to undervalue them following years of declining prices.

But since this relationship is not consistent enough to depend on alone, as stated above, and since the effects of profits or losses the previous year are likely to be measured, in part at least, by the proportion stored this year, it is better to use storage holdings. But even after allowing for storage holdings, and the other factors, the change in egg prices the previous year is still helpful, in a minor way, in explaining the change in egg prices this year (table 2 and figure 9).

5. Average seasonal rise

After allowing for the estimated effects of all four factors the average of the residuals from 1925 to 1937, inclusive, is 3.6 cents up. This is largely due to the average seasonal rise in egg prices from spring to fall.

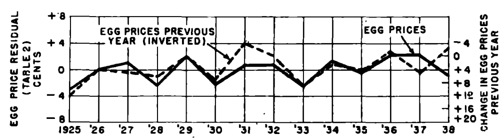

FIGURE 9.—Change in egg prices from spring to fall in the previous year compared with change in egg prices from spring to fall after allowing for the other principal factors (Factors 1, 2, 3, and 5) 1925-38.

OTHER MEASURES OF THESE FACTORS

1. Other measures of proportion stored.—Proportion stored can be measured in several ways. Data on the rate of storing are available at 4, 26, and 35 markets and United States total. The supply may also be measured by receipts at 4 markets weekly and by the number of eggs laid per farm flock on the first day of each month. It does not matter much which measures are used. The quantity being stored fluctuates so much more than production or receipts that all measures of proportion stored are very similar. In fact, the quantity being stored, without reference to the quantity produced, serves the purpose about as well as the proportion stored. It is desirable to use several measures of proportion stored as checks on each other.

Year-to-year variations in the quantity of frozen eggs in storage are quite similar to the variations in the quantity of shell eggs. Hence, shell eggs can be used alone as a measure of proportion stored. However, eggs even though frozen are still eggs; hence, it is more reasonable to allow for their effect on shell egg prices than to neglect them. Stocks of frozen eggs have been rising for many years and stocks of shell eggs have been declining, but the two kinds, when added together, have maintained a fairly level trend. Because of the intercorrelation it is impossible to determine just how much weight to give frozen eggs as a factor on shell egg prices. However, good results can be obtained by any one of several assumptions ranging all the way from one-half of the frozen to all of the frozen added to shell egg stocks.

2. Other measures of egg production in the fall.—This may be measured by receipts at 4 markets or receipts at the Mid-West primary markets or by the number of eggs laid per farm on the first of each month.

3. Other measures of change in all food prices.—Change in the average price of all meat can be substituted for all food prices.

Various efforts have been made to use the supply of other foods such as meats, fruits, and vegetables in place of all food prices, but we have been unable to find any significant relationships.

FACTORS AFFECTING PROPORTION STORED

1. Production during the spring.—This is not controlling, but does affect the quantity stored somewhat.

Egg production during the spring is determined very largely by the number of hens laying during the spring. The number of hens to lay during the spring is indicated quite well by the number per farm on January 1 and even by the number of chicks per farm the previous July 1. However, in recent years the number of eggs laid per hen has been gradually increasing.

2. Previous profits and losses.—The quantity stored during the spring is also affected by the profits or losses realized by those who took the risks of owning storage eggs the previous year. Losses tend to lower prices the following spring, which increases consumption and decreases the quantity stored.

3. Price after supply and demand.—When the price of eggs is low compared with current supply and demand conditions a small proportion is stored, and conversely. However, since changes in prices are rather promptly reflected in consumption, it is better to use the actual proportion stored rather than price as a barometer thereof.

FACTORS AFFECTING FALL PRODUCTION

1. Temperature.—One of the principal factors causing changes from year to year in egg production in November and December is temperature.

2. Layability.—Another important factor is the average laying ability of the hens.

This is a difficult factor to measure because it is so much affected by temperature in November and December. But there is some evidence in the rate of lay in the summer and early fall months when it is not so seriously affected by abnormalities of temperature.

Layability during the fall appears to be, in part at least, the result of the size of the flocks carried into the previous spring. In years when the size of the flocks is being curtailed during the winter and spring the less efficient birds are more thoroughly culled out than in years when producers are expanding their flocks. This means more eggs per old hen the following fall. It also means a large proportion of pullets the following fall, which increases the production per hen.

3. Feed supply and feed-egg ratio.—Years of large corn crops are years of abundant feed and a low feed-egg price ratio. This has some influence on fall egg production but is not a controlling factor.

4. Number of hens and pullets.—This is also a minor factor. Changes from fall to fall in the number of hens and pullets are so small compared with the violent changes occurring in the rate of lay that they are practically negligible from an outlook viewpoint.

5. Size of the chicken crop.—This affects fall production through the number of pullets. However, since the number of layers is of minor importance (see previous paragraph) the size of the chicken crop is not a very useful barometer of the fall lay.

6. Temperature in August.—There is some evidence that a hot August increases fall egg production. However, this is uncertain and minor except in one or two years.

7. Eastern production.—The rapid increase in eastern egg production in recent years may have

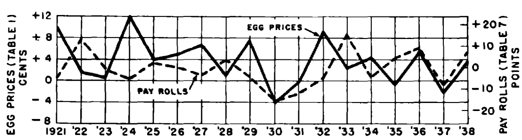

FIGURE 10.—Change in factory payrolls from spring to fall compared with change in egg prices from spring to fall, 1921–38.

increased fall production more than it has increased spring production. We have been unable to prove this, however, and since we can explain the rise in fall production satisfactorily without using this factor we are inclined to consider it as of minor importance when estimating fall production.

FACTORS AFFECTING ALL FOOD PRICES

We know of no way to forecast the change in all food prices from spring to fall until August or September. By that time the influences which determine the change from March-June to August-December have usually become effective enough to be apparent in the change which has already occurred in all food prices.

The corn crop is apparently a factor, but it is not forecastable until August.

Changes in purchasing power, of course, affect the average price of all food, but they are also difficult to forecast.

FACTORS OF NEGLIGIBLE IMPORTANCE

1. Purchasing power of consumers.—This factor affects season to season changes in the price of some foods but apparently has little influence on the change in egg prices from March-June to August-September (table 7 and figure 10). Even after allowing for other factors changes in purchasing power have no apparent relationship with changes in egg prices from March-June to August-December.

2. Meat supply.—We were unable to find any very controlling relationship between meat supplies and profits or losses on storage eggs.

3. Eastern production.—It is sometimes thought that the rapid increase in egg production in the Eastern States in recent years has had a depressing effect on profits on storage eggs. Undoubtedly the larger proportion now being produced in the Eastern States has reduced the demand for Western eggs somewhat. But it is not clear that it has reduced the demand for Western eggs more in the winter than in the previous spring. Because of this and also because we can find no convincing evidence in our correlation studies of the importance of this factor, we are forced to class it as negligible.

4. Futures market.—The futures market is of no value when estimating the probable change in egg prices from spring to fall. It is based very largely on the spot price plus the cost of carrying.

5. Imports and exports.—Apparently the quantity is too small to be significant.

ACTUAL CHANGE IN EGG PRICES

The earliest that the actual change from March-June to subsequent prices is useful as a barometer of profits or losses for the entire season is early in August. The size of the storage holdings is sometimes reflected in egg prices by June but not consistently until in August.

CONCLUSION

The principal factor affecting profits and losses on storage eggs is the proportion stored in the spring. When the proportion stored is below average, profits are likely, and when the proportion stored is above average, losses are likely. There have been exceptions to this rule, of course, but it has proved to be controlling in a large proportion of the years. Compared with this factor all others are of minor importance.

SUMMARY

There are many factors which it is reasonable to believe affect profits on storage eggs. There are many measures of each factor. Only a few factors are of major importance judging by the experience of former years. All of the other factors have such a small influence on egg prices that they should be neglected entirely when considering the outlook.

The experience of the last nineteen years shows that profits tend to follow losses and losses tend to follow profits in a somewhat regular 2-year cycle. If this tendency were a little more regular there would be no need of studying the factors which have determined it in the past in order to judge the outlook for the future. But since it sometimes is profitable or unprofitable two years in succession, and sometimes is about on a "break even" basis, it is desirable to study past experience to find bases for judgment on the year ahead.

Judgment alone is not dependable because there are many perfectly reasonable theories which do not work out in practice and some factors which are less important than others. Hence, it is necessary to test the reasonable theories in the light of past experience; discarding those which have evidently not been important in former years and weighting each of the other factors according to the degree to which it was influential in the past.

The following factors, when combined, furnish a rather complete explanation of changes in egg prices from spring to fall in former years.

1. Proportion stored by August 1.
2. Change in egg production from spring to fall.
3. Change in all food prices from spring to fall.
4. Change in egg prices from spring to fall of the previous year.
5. Average seasonal rise.

The principal factor affecting profits and losses on storage eggs is the proportion stored in the spring. When the proportion stored is above average, profits are likely, and when the proportion stored is below average, losses are likely. There have been exceptions to this rule, of course, but it has proved to be controlling in a large proportion of the years. Compared with this factor all others have been of minor importance.

EGG PRICES IN ENGLAND

By O. J. Beilby, *Agricultural Economics Research Institute, Oxford, England*

EGG SUPPLIES

One of the most striking features of British agriculture in the postwar years has been the rapid expansion of the poultry industry. In 1934 the output of eggs in Great Britain was 36,660,000 great hundreds[1] compared with 17,770,000 great hundreds in 1925 and 12,100,000 great hundreds in 1913. (In terms of the American case the figures would be 12,220,000, 5,923,000, and 4,033,000 cases, respectively.)

This expansion has been due both to an increased output per bird and to an increase in the poultry population. The output per bird is estimated to have increased from 75 in 1908, and 100

[1] A "great hundred" is 10 dozen, or 120 eggs.

in 1925 to 120 in 1930. The number of fowls increased from 33,000,000 in 1913 and 39,000,000 in 1925 to 69,000,000 in 1934.

Imported supplies of eggs have not, however, increased to the same extent, and are only slightly higher than in the prewar years. In fact, between 1928 and 1933 the expansion of home production was accompanied by a decrease in the volume of imports. As a result the proportion of the nation's egg supply produced at home, which was around 50 percent from 1924 to 1928, had, by 1934, risen to about 70 percent. (Table 1.) During this period, therefore, home production to some extent displaced imports.

Since 1934 there has, however, been some retrogression in the economic situation of the industry. The number of fowls in Great Britain which reached a maximum of 69,000,000 in 1934 had fallen to 59,500,000 by 1938. At the same time imports increased from a minimum of 18,374,647 great hundreds in 1933 to 24,731,642 great hundreds in 1937.

TABLE 1.—*Estimated consumption of eggs in shell in the United Kingdom, 1913-37*

Year	Total supplies	Per capita consumption			Source	
		Total	Home produced	Imported	Home produced	Imported
	1,000 great hundreds	*Number*	*Number*	*Number*	*Percent*	*Percent*
1913	33,750	111	40	71	36	64
1924	41,590	111	58	53	52	48
1928	53,720	144	74	70	51	49
1931	60,930	158	91	67	58	42
1934	58,400	150	102	48	68	32
1937	61,300	156	93	63	60	40

These changes in the fortunes of the British poultry industry—the rapid expansion up to 1934 and the subsequent less favorable situation—are the result of two main groups of factors. First, the market prices at which eggs and poultry may be sold and feed bought. Second, changes in the technical efficiency of production in the industry. This includes changes not only in the methods of feeding, management, and breeding of sound stock, but also in the incidence of disease among poultry flocks. The disease problem has, in fact, become extremely important in the last few years. This paper is concerned mainly with the first group of factors, the fluctuations in egg prices and the relation of egg and feeding stuff prices in recent years.

PRICES

Regular price quotations for English eggs are available only since 1906. The relationship between egg prices, agricultural prices, and the price of poultry from that time until 1937 is shown in figure 1.

The index numbers of egg prices are based on the average prices of first and second quality eggs at town and country markets in England and Wales. In general, it may be said that movements in the prices of lower quality and of imported eggs follow fairly closely those of the top grade.

Of the imported eggs coming on to the British market, Irish, Danish, and Dutch command the highest prices. They realize from 1s. to 5s. per great hundred less than English eggs according to

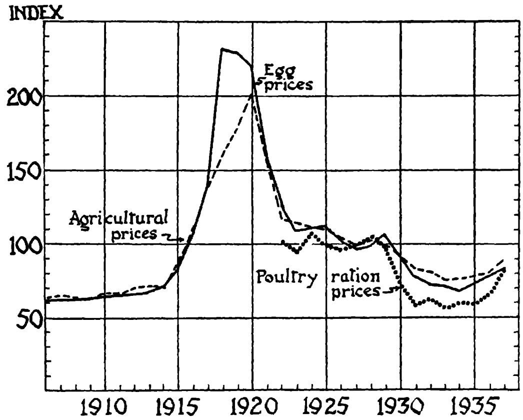

FIGURE 1.—Index numbers of the prices of eggs, of all agricultural products and of a poultry-feeding-stuffs ration, 1906-38. (Base 1927-29 = 100.)

TABLE 2.—*Average annual wholesale prices per 120 of certain kinds of eggs in England, 1924-37*

Year	English (ordinary) 1st quality		English (ordinary) 2nd quality		National Mark Standard		Irish 16 lb.		Danish $15\frac{1}{2}$-16 lb.		Dutch		Polish	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*	*s.*	*d.*
1924	20	7	19	4		-	19	5	19	1	20	1		-
1925	21	0	19	6		-	19	11	20	4	19	6		-
1926	19	2	17	6		-	18	3	17	0	17	4		-
1927	18	6	16	8		-	17	5	16	2	16	3	10	4
1928	18	9	16	10		-	17	5	16	3	16	7	10	2
1929	20	0	18	4	21	2	17	8	17	5	16	5	11	4
1930	17	3	15	7	18	2	15	0	13	3	13	10	9	2
1931	14	9	13	4	15	8	12	10	12	5	11	7	7	8
1932	13	9	12	6	14	9	12	9	10	3	12	5	7	3
1933	13	6	12	2	14	7	11	9	11	0	9	11	7	8
1934	13	0	11	9	13	11	11	7	11	2	10	8	7	0
1935	13	10	12	6	14	8	12	3	11	2	10	7	7	4
1936	14	11	13	7	15	6	12	2	11	7	10	11	7	2
1937	15	10	14	4	15	11	12	6	11	8	11	4		-

their quality and the season of arrival. In 1936, for instance, when English first quality eggs averaged 14s. 11d. per great hundred, Irish eggs of similar weight fetched 12s. 2d. and Danish 11s. 7d. (table 2). The prices of Polish and Chinese eggs, however, move somewhat irregularly and only realize from 50 or 60 percent of the prices of English eggs. Thus while Irish and Danish eggs must be regarded as largely competitive with home produced supplies, imports from Poland and China cater for a rather different market. Consumers of these cheap eggs have a very elastic demand and it is doubtful if British eggs will ever succeed in competing with such low priced supplies unless there is a very drastic reduction in the price of British eggs. British, Irish, and Danish eggs are, however, more nearly competitive with one another and there is no reason why the home-produced article should not succeed in taking the place of the imported, provided the price is low enough.

The foregoing changes in prices are the result of three main types of price movement: (1) Changes in the value of money affecting the general level of prices (2) changes in the demand for eggs (3) year to year changes in supply. There is, however, a fourth type of price movement, seasonal changes from month to month due to the natural variation in production.

Seasonal changes in price are important for a number of farm products, and this is particularly true of eggs. The prosperity of the poultry farmer probably depends more on month-to-month than on annual price changes. This variation tends to remain relatively constant from year to year. An index of the monthly variation in price has been computed for the years 1910-14, 1925-27 and 1935-37 (table 3). The extent of the seasonal variation has not shown any noticeable tendency to diminish in the postwar period as might have been expected to result from improvement in methods of management and increased egg yields. The price is at a minimum in April or May and reaches a maximum in November. In 1935-37 the maximum price in November was $2\frac{1}{2}$ times the minimum in May. This is a greater seasonal variation than in the United States probably because there is much less storage of eggs on a commercial scale in Great Britain during the spring peak of production.

TABLE 3.—*Index numbers of seasonal variation in egg prices*

Month	1910-14	1925-27	1935-37
January	113	118	97
February	100	105	93
March	73	68	69
April	66	61	60
May	68	63	65
June	75	66	76
July	83	78	92
August	94	94	108
September	101	107	114
October	122	137	135
November	153	161	151
December	152	143	140
Average	100	100	100

FACTORS AFFECTING PRICES

It is obvious that these changes in prices are caused by very many factors, political and social, as well as economic. Many of them are impossible of statistical measurement. Of those which can be measured three have been selected, as among the more important, for the purpose of analyzing their relationship with prices.[2]

The first factor is demand, represented by an index of consumers' spending power. The latter is based on the total money wages of the community and, after adjustment for certain of the more rigid expenditures, such as rent, should indicate the amount of money available for food expenditure. It is really a composite measure of changes in the value of money and of consumers' willingness and ability to purchase eggs.

The second factor is the supply of home-produced eggs. Monthly estimates of production were used, computed from the Ministry of Agriculture's annual output figures and an index of the seasonal variation in marketings. These supplies show a regular seasonal variation, which is the inverse of the seasonal changes in prices.

The third factor is the volume of imported supplies of eggs in shell. Here the seasonal variation is much less. There are, however, two peak months for imports, May and October. The former is due to large imports from the European countries, the latter to imports from the Southern hemisphere. Some of the main changes in the home output and in imports in recent years were indicated at the beginning of this paper.[3]

A correlation analysis of the relationship between these three factors and egg prices showed that they accounted for some 90 percent of the changes in monthly prices during the period 1925-37.[4] The actual monthly prices since 1934 and the prices estimated from the regression equation are shown in figure 2.

The correlation analysis shows the large part played by demand in year-to-year price changes. For each 1 percent increase in the index of demand egg prices increased by 1.6 percent. A change in home production of 1 percent caused an inverse change in prices of 1.1 percent. Prices, however, were less sensitive to the level of imports, where a 1-percent change caused an inverse price change of only 0.2 percent.

Seasonal price changes were very largely determined by month to month changes in the home-

[2] It is not suggested that these are the only important factors, but for purposes of statistical analysis, it is desirable to limit the number of variables considered.

[3] The monthly data on output, imports, demand, and prices on which the statistical analysis is based are given in "Egg Prices—A Study of the Factors affecting Prices and Production" by O. J. Beilby, Appendix II, pp. 59-63, Agricultural Economics Research Institute, Oxford, 1937.

[4] The correlation is based on the method of analysis of covariance, as applied to economic data in an article by A. B. Bailey in the Journal of the American Statistical Association for September 1931. The regression equation (within years) was:
$\log X_1 = 1.0916 - 1.1417 \log X_2 - 0.2116 \log X_3 + 1.6623 \log X_4$, where X_1 is the monthly price of eggs in shillings per 120, X_2 is monthly home output in millions, X_3 is the monthly imports in millions, and X_4 is the index of demand. The coefficient of multiple correlation $\bar{R}_{1.234} = 0.95$.

produced supply. The percentage variations in the home output from month to month are so much greater than with demand that they more than offset the greater sensitivity of prices to changes in demand. The latter varies only slightly from month to month. Moreover, while seasonal changes in imports result in a change in egg prices in the opposite direction, from year to year there is a positive correlation between imports and prices, that is, an increase in imports is associated with an increase in prices.[5] This would suggest that between one year and another an increase in egg prices stimulates an increase in imports, while from month to month an increase in imports depresses prices. This has been confirmed by the increase in imports between 1934 and 1937 which was associated with an increase in egg prices.

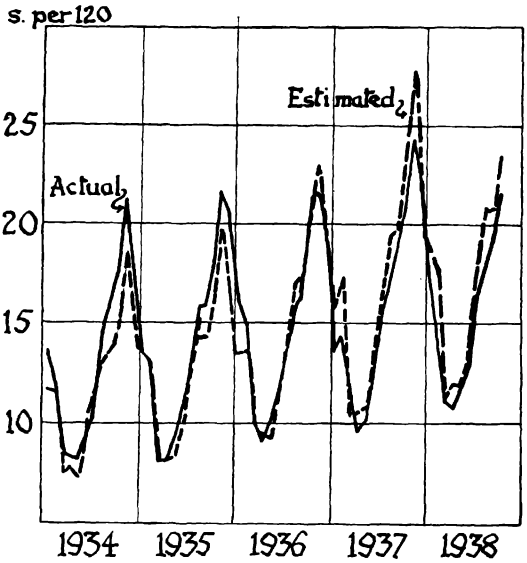

FIGURE 2.—Actual changes in the monthly prices of eggs and estimated monthly prices obtained by correlation analysis, 1934–38.

From this analysis it is possible to calculate the changes necessary in any of these factors to bring about an increase of, say, 10 percent in egg prices. To have raised egg prices by 10 percent or 1½d. per dozen in 1937 would have required a reduction of home production of 2,700,000 great hundreds, or of imports by 9,090,000 great hundreds, or an increase of 6 percent in the index of demand. If it is one of the objectives of agricultural policy to promote the expansion of the poultry industry then only the second or third alternatives are possible. As any drastic reduction of imports is likely to be politically inexpedient, there remains only the possibility of increasing demand. This might possibly be done by an advertising campaign on behalf of British eggs, but otherwise consumer demand is dependent on industrial prosperity. So it appears that with eggs, as with most other products of British agriculture the prosperity of the farmer and of the industrial worker rise and fall together.

Feeding stuff prices

There is, however, another very important factor for the poultry farmer, the level of feeding stuff prices. The latter are estimated to form about 60 percent of the total costs of egg production. It is the ratio of egg prices to feeding stuff prices that determines profits. Index numbers of the price of a representative feeding stuff ration are given in figure 1, above. Analysis shows that changes in the number of fowls hatched bear a close relationship to changes in the "egg-feed ratio" at the time of hatching and during the previous season.[6] Thus, it is really the "egg-feed ratio" which determines the future level of production. The numbers of poultry and the output of eggs in Great Britain increased in the period 1924–34 mainly because of the relatively low prices of feeding stuffs then prevailing, though part of the increase appears to have been due also to greater efficiency resulting in lower costs of production. Though in the short run, higher egg prices mean a greater income for the producer, within a year or two production will increase and consequently egg prices will fall again. Thus, higher egg prices alone are not likely to bring permanent prosperity to the poultry farmer. But if expansion of production takes place not because of higher egg prices alone, but as a result of lower costs of production (including lower feed costs), then it is more securely grounded. At present the chief obstacle to lower costs is the heavy incidence of disease and the high mortality rates in most flocks. During 1937 and part of 1938 the high cost of feeding stuffs was also an important factor.

SUMMARY

The rapid expansion of the poultry industry in the postwar years is one of the outstanding features of British agriculture. This expansion reached a peak in 1934 with a fowl population of 69,000,000. By 1938, the number of fowls in Great Britain had fallen to 59,500,000. These changes are the results of two main groups of factors:

1. The market prices at which eggs and poultry may be sold and feed bought.

[5] The equation for price changes (between years) was:
$\log X_1 = 1.0955 - 0.5689 \log X_2 + 0.1397 \log X_3 + 0.5656 \log X_4$
$\bar{R}_{1.234} = 0.94$.

[6] The regression equation was:
$\log X_1 = -0.0394 + 0.4547 \log X_2 + 0.1905 \log X_3 + 0.1413 \log X_4$, where X_1 is the number of fowls on June 4th under 6 months old, X_2 is the egg-feed ratio 3 to 7 months previously, X_3 the egg-fed ratio 15 to 19 months previously and X_4 a time factor to allow for the increase in productive efficiency. This time factor, being logarithmic, increases at a decreasing rate and so allows for the increasing incidence of disease, which has been one of the main obstacles to greater efficiency in production in recent years. The coefficient of multiple correlation $\bar{R} = 0.97$.

2. Changes in the technical efficiency of production.

Statistical analysis of the behavior of egg prices in England over a period of years indicates that the profits of egg production are determined in the short run by daily and weekly changes in egg prices; in the middle period—from about a month to two years—by the "egg-feed ratio"; in the long run by the "egg-feed ratio" and also by the technical efficiency of production and its effects on costs. Feeding stuff prices are determined largely by the world cereal situation, and efficiency in production by farmers themselves.

In this paper some indication has been given of the main kinds of changes in egg prices and of the factors affecting them. This should make it possible to forecast future changes in one of the three important factors affecting the prosperity of the poultry farmer, namely, egg prices.

HABITS IN CONSUMPTION OF EGGS IN NEW YORK CITY

By LILA F. KNUDSEN *and* F. L. THOMSEN,[1] *Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C., U. S. A.*

The poultry industry is vitally concerned with the habits of American families in regard to egg consumption. Such questions frequently arise as, How many eggs does an average urban family use? Do families of one nationality or race use more eggs than those having other national or racial origins? How does the income of a family affect the number of eggs purchased? Do families of six use twice as many eggs as families of three? Do such factors as income, size of family, and nationality cause the housewife to omit eggs from her shopping list?

In this report an attempt has been made to answer some of these questions by means of an analysis of data that were obtained from a survey of egg consumption in New York City, covering about 60 days during March, April, and May of 1935. Enumerators made the survey, through a daily house-to-house canvass of more than 18,000 families in four of the five boroughs of New York City (the borough of Richmond was omitted). A very careful random-sampling procedure was followed, so that the number of families interviewed in each of the 70 districts, in which the survey was divided, was in proportion to the total number of families living in those districts in 1930. The questionnaire used asked for data on the purchase of eggs for the previous 7 days. Each family was classified also according to approximate weekly income, the number of persons in the family, and the nationality or race of the head of the family (native white includes only white gentiles of native born parents).

Two important questions relating to consumption of eggs are: (1) Whether or not the family bought eggs and (2) if eggs were purchased, how many? It is necessary, of course, to relate the question to some specific time period, in this case the week preceding the time of interview.

On the average, about 90 percent of the 18,000 families interviewed bought some eggs during the week. The fact that the Christian observances of Lent and Easter, and the Jewish Passover occurred during the period in which the survey was taken may have caused this percentage to be a little higher than usual. Possibly not as many eggs are used on Easter morning as was customary some years ago, but eggs continue to have a prominent place in Passover feasts. However, not as much difference in the percentage of families using eggs occurs between nationalities as might be expected. (In this study, use and purchase are considered as synonymous, although families classified as purchasing no eggs during the week may have been using eggs purchased some time previously.) Almost 94 percent of the families of Jewish extraction purchased some eggs during the week prior to interview. Ninety-one percent of the native white families were purchasers of eggs, 90 percent of the north European, 87 percent of the Negro families, and almost 87 percent of the families classed as Mediterranean. The comparison of percentages of egg consumers according to nationality is shown in figure 1. It also appears that only 70 percent of the families of only 1 person purchase eggs and 85 percent of families of 2 are purchasers. Further increases in size of family appear to have little or no effect on the proportion buying eggs.

Differences in the average weekly income of families above $25 appear to have little or no effect on the housewife's decision to buy eggs, as shown in figure 1. However, in the lower income groups 27 percent of those families having incomes of less than $6 per week did not buy eggs, 85 percent of those with incomes of between $6 and $15 per week bought some eggs, and 90 percent of families with incomes between $16 and $25 bought eggs. Because of the high percentage of families buying eggs and, with one exception, the apparent lack of relationship between the variables con-

[1] The procedure followed in the analysis is similar to that used in the consumption section of the "Economic Survey of the Live-Poultry Industry in New York City" by G. W. Sprague, Alexander Sturges and James Radabaugh, U. S. Department of Agriculture Miscellaneous Publication No. 283. In both studies the enumerators were furnished by the Emergency Relief Bureau of New York City.

sidered, no correlational procedure was attempted. The lowest income group also had the lowest average number of persons in the family, but beyond the two low groups no relationship was found between size of family and income of the families included in this study.

With respect to the second question regarding egg consumption, namely, the quantity bought by those families purchasing eggs, the data indicate that once the decision has been made to purchase eggs, the number of eggs purchased is very definitely affected by the size of family, by average weekly income, and, to a lesser extent, by the race

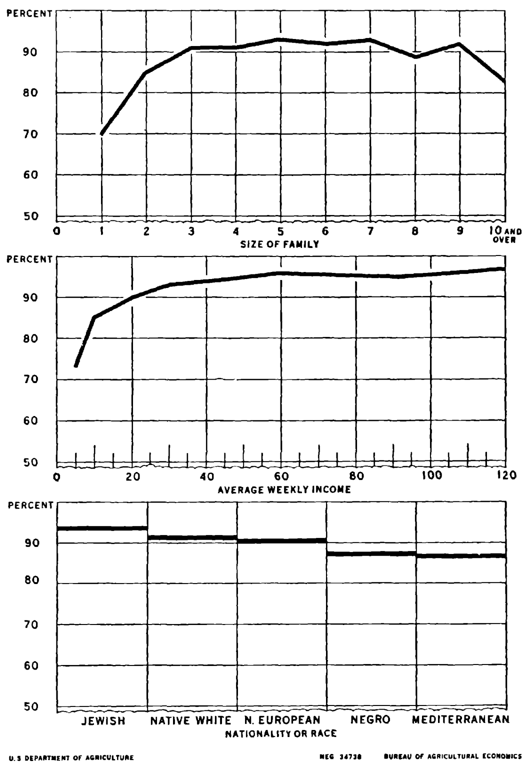

FIGURE 1.—Average proportion of families using eggs, according to size of family, income, and nationality, New York City, spring 1935.

or nationality of the purchaser. Because of the small range in the prices paid for eggs during this period and because prices paid are correlated with the income of the purchaser, no attempts were made to include prices in this study. Prices were at a seasonal low and were fairly constant over this period, and whatever effect the little variation that may have occurred in prices had on the amount consumed by the families of various sizes and nationality has been largely eliminated by using income as a third variable. Undoubtedly variation in price over a period of time has a marked effect on the consumption of eggs, but during this period prices varied relatively little.

The method employed here for isolating relationships from other factors involved was applicable because of the abundance of data and makes no assumption of linearity of regression lines between the considered variables. It may be best explained by an illustration of a section of the data.

The procedure of isolating the relationship between the two factors, the number of eggs purchased and the nationality of the family, from the influence of the two remaining variables, size of family and weekly incomes is described below. (See also table 1.)

This particular cross-section of the data (table 1) shows the number of families and average number of eggs purchased for each of the six nationality groups, considering *only* those families consisting of three persons and having an approximate average weekly income of $16 to $25. In statistical terminology, two of the four variables are considered to be held constant. Any variation of the total average number of eggs purchased by

TABLE 1.—*Average number of eggs purchased by families of three persons with average weekly income of $16 to $25, by race or nationality, New York City, March-May, 1935*

Nationality of family	Number of families	Average number of eggs purchased	Adjusted average number of eggs purchased
	Number	*Dozens*	*Dozens*
Native white	213	1.47	1.77
North European	324	1.45	1.75
Jewish	180	1.67	1.97
Mediterranean	156	1.49	1.79
Negro	60	1.34	1.64
Other	38	1.64	1.94
Total	971	1.50	1.80

all nationalities (1.50 dozen) may be considered as due to the two factors held constant. This particular average is 0.30 dozen below 1.80 dozen, the average number of eggs purchased in any week by the entire group of 16,000 families. Adding this number (0.30 dozen) to each of the averages for the various nationalities removes the variation due to the constant factors. The last column in table 1, the adjusted average number of eggs purchased, shows the variation in average purchases due to nationality alone with the influence of both income and size of family removed.

Figure 2 shows the variation due to nationality in the number of eggs purchased when variation due to the average weekly income and size of family has been eliminated. The Jewish group had the highest average consumption of eggs, and since it exceeds that of the other groups by more than the sampling allowance there can be little doubt from a sampling standpoint that the number of eggs used among Jewish families was definitely greater than the amount used by families of other nationalities. The Negroes have the lowest average consumption, differing by a significant amount from the average consumption of any other nationality. Mediterranean, native white, and north European have about the same

Of the three independent variables considered, the number of persons in the family has the greatest effect on the number of eggs consumed. Figure 3 shows this relationship. The line connect-

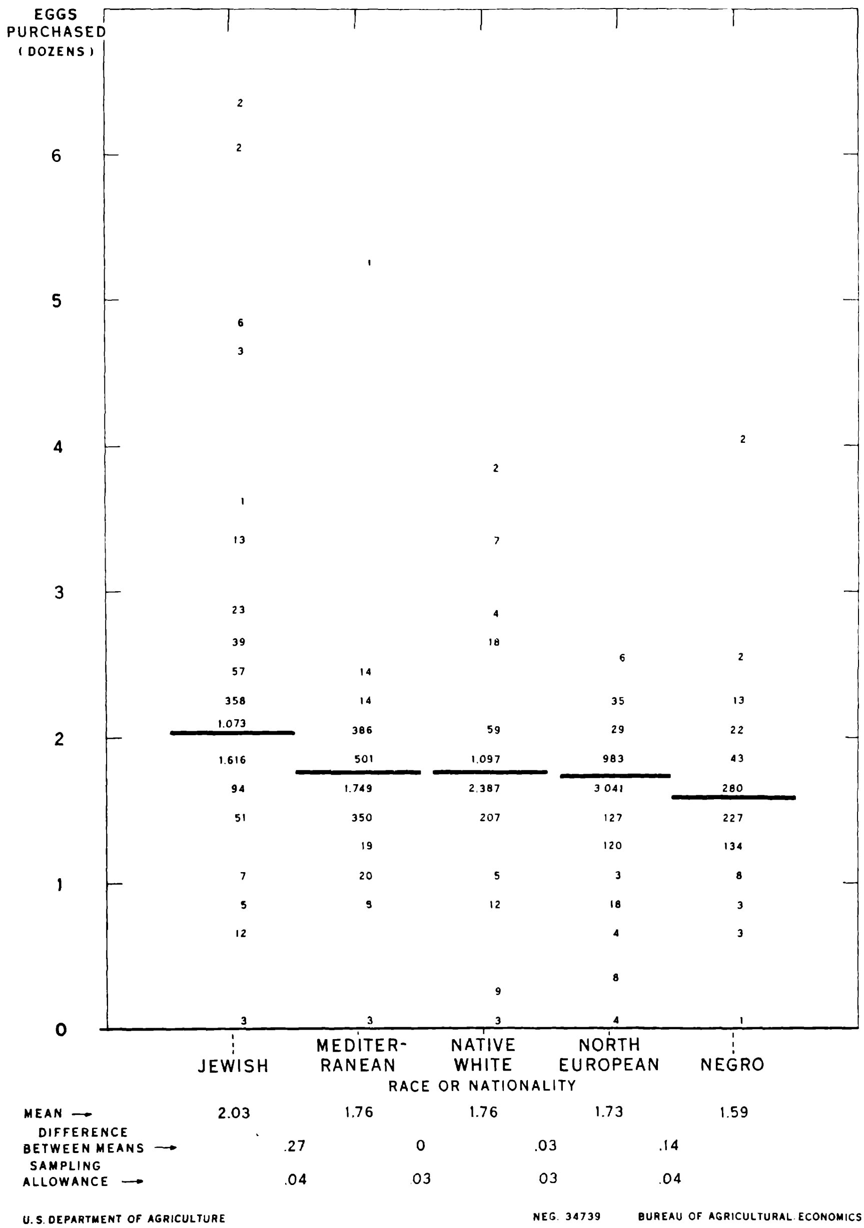

FIGURE 2.—Dozens of eggs purchased by families of different nationality, adjusted for income and size of family, New York City, March–May, 1935.

average consumption, 1.76 dozen, 1.76 dozen, and 1.73 dozen, respectively. The fact that the Jewish Passover and Easter occurred during the period under consideration may have affected these comparative figures to some extent.

ing the means of the size of family groups departs very little from a linear regression line. The correlation ratio calculated from these data is 0.50 and shows a definitely significant relationship. A family of four does not buy twice as many eggs as a family of two. The average difference between means of groups whose family size differs by but one person is two-tenths of a dozen eggs, indicating that if one additional person came to live with an average family in the spring of 1935, purchases of eggs would be increased by about three eggs per week.

The income of a family also has some effect on the number of eggs purchased in any one week, especially if the income exceeds $15 per week. The line connecting the average dozen purchased by each income group as shown in figure 4 indicates the relationship between income and purchases of eggs after the effect of nationality and size of family has been removed. The correlation ratio calculated from these data is 0.30 and is definitely significant.

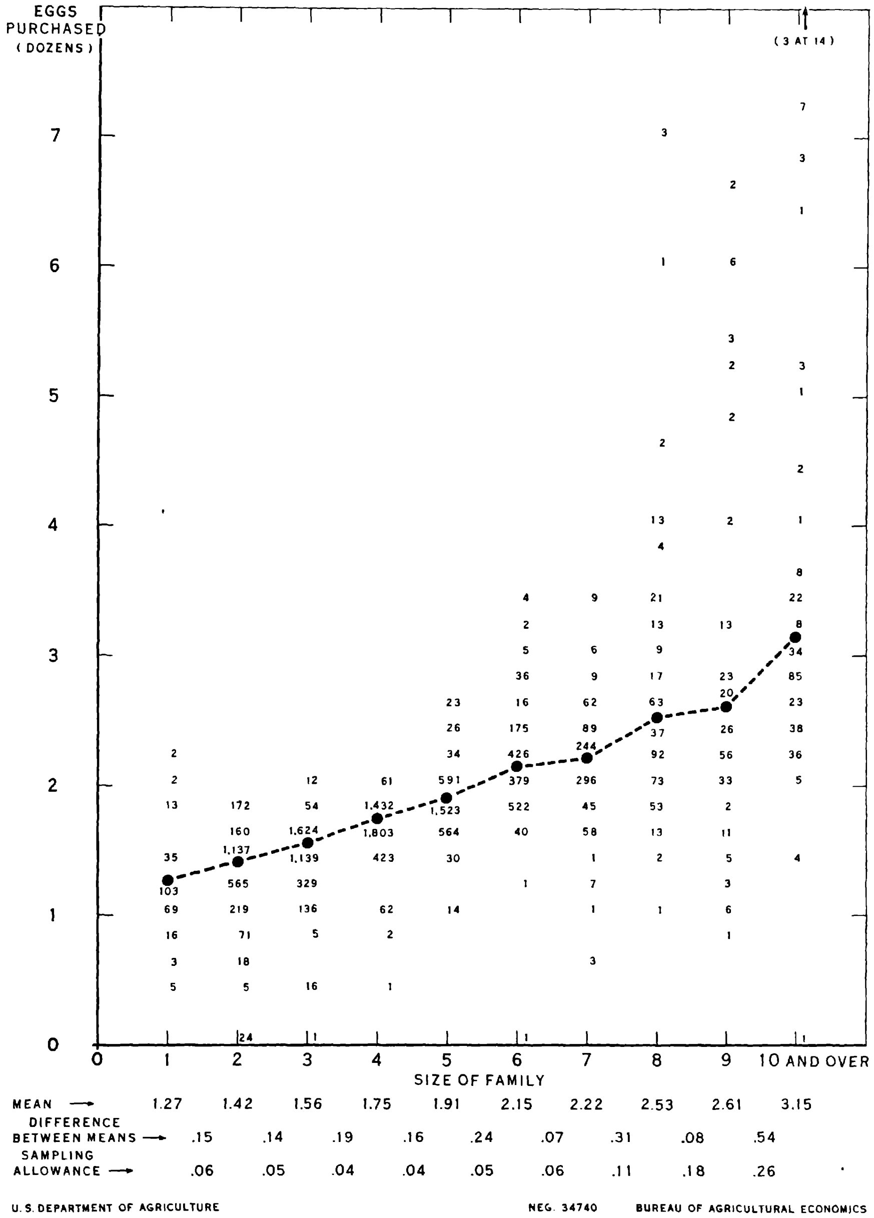

FIGURE 3.—Dozens of eggs purchased by families of different sizes, adjusted for nationality and income, New York City, March–May, 1935.

It is necessary to distinguish between consumption differences and consumption changes. This study shows only existing differences in egg consumption between various groups at the time and place of the survey. It does not necessarily follow, for example, that an increase in the income of any group, bringing it up to that of the next higher group, would result in bringing egg consumption up to the other group's average. The consumption habits established at any one level of income are at least partly carried over, perhaps many years being required to effect the eventual adjustments. Thus, to raise the incomes of all families to the level of the group reporting maximum egg consumption per family would not raise egg consumption immediately by a number superficially indicated by the difference in egg consumption between income groups. In order to deduce, from the results of this study, the probable effects

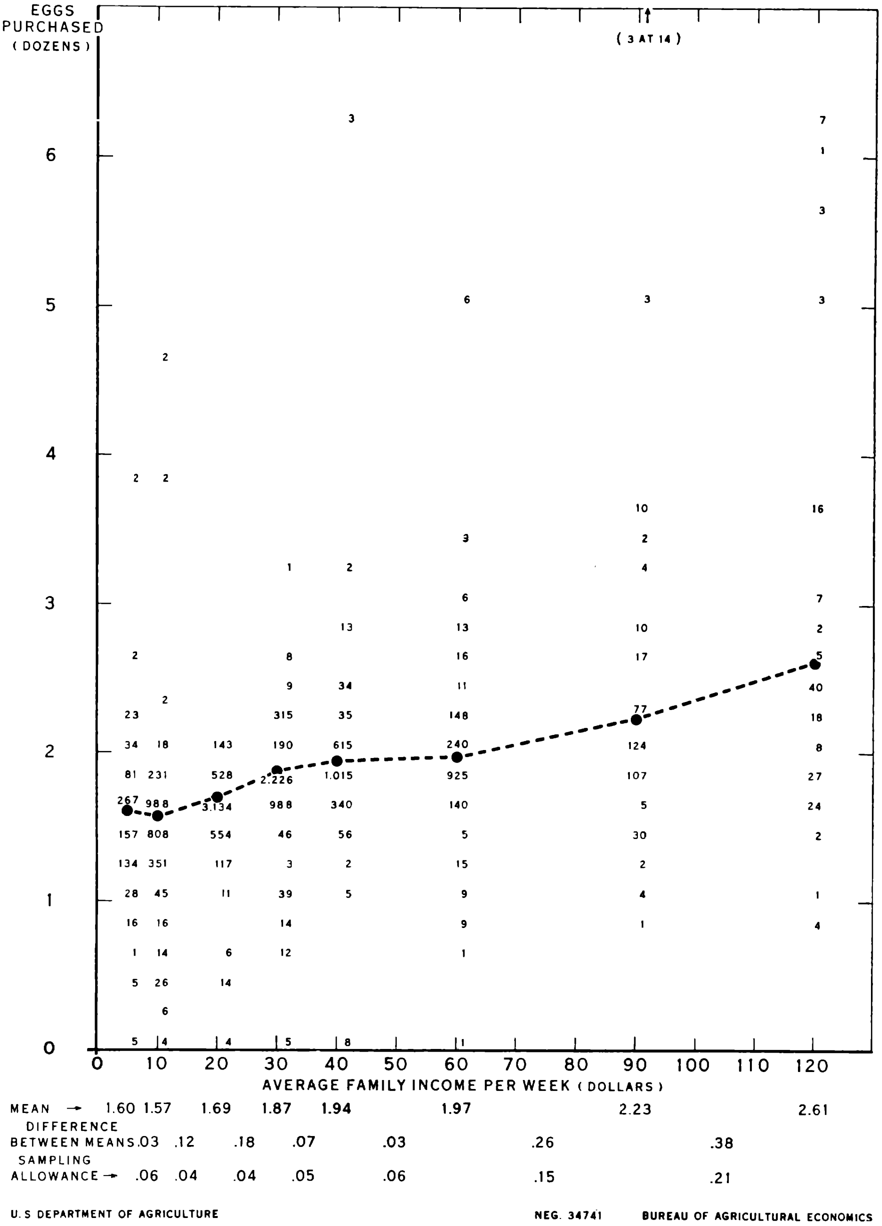

FIGURE 4.—Dozens of eggs purchased by families having different incomes, adjusted for nationality and size of family, New York City, March–May, 1935.

on egg consumption of changes in income or size of family, it is necessary to assume that differences and changes are identical, which may or may not be justified in specific instances.

These are the relationships that are evident from this study of urban egg consumption during a period of low prices for eggs. Though the relationships are expected to be nearly the same throughout the year, nothing definite can be stated as to how they might differ in a period of high egg prices.

The study shows that factors other than those considered also affect the number of eggs consumed as indicated by the large scatter about the means. Although most of the differences in egg consumption due to differences in income, size of family, or nationality are significant, other factors not considered here were responsible for even greater differences in consumption as between families of the same size, nationality, or income. It appears that personal preferences and experiences (perhaps with a bad egg during an impressionable period of life) related to a variety of factors other than the more obvious differences in family characteristics dealt with here, are also responsible for the variation in egg consumption among families in New York City.

SUMMARY

The poultry industry is vitally concerned with habits of American families in regard to egg consumption. This study attempts to analyze some of these habits by showing how nationality, size of family, and income affect both the proportion of families using eggs and the number of eggs used. The data analyzed were obtained from a survey of egg consumption in New York City covering about 60 days during March, April, and May of 1935. The enumerator-questionnaire method was used and a very careful random sampling procedure was followed.

About 90 percent of the 18,000 families interviewed bought some eggs. The proportion of families using eggs was affected by nationality only slightly, by size of family only when there were less than three persons in the family, and by average weekly incomes only when they were below $25.

The number of eggs bought by families purchasing some eggs was affected most by size of family. The average difference between means of groups whose family size differs by but one person is two-tenths of a dozen eggs per week. The income of a family also has some effect especially if it exceeds $15 per week. The Jewish people have the highest average consumption of eggs and the Negros the lowest.

This study shows only existing differences in egg consumption between various groups at the time and place of the survey, and it cannot be assumed that these differences in consumption are identical in all cases with changes in consumption, since consumption habits formed in one period may be carried over into another. Although most of the differences in egg consumption due to differences in income, size of family, or nationality are statistically significant, other factors not considered here affect the number of eggs consumed, as indicated by the large scatter about the means.

THE IMPROVEMENT OF NATIONAL AND INTERNATIONAL POULTRY STATISTICS

By J. CLYDE MARQUIS, *American Delegate, International Institute of Agriculture, Rome, Italy*

The improvement of the statistics and other information that measure the progress of the poultry industry has been moving forward at an increasing rate during the last decade. Comments on the particular difficulties met in collecting poultry statistics are constantly heard, yet progress in some countries has been relatively rapid.

This subject has occupied some of the attention of the World's Poultry Science Association since it was originated in 1912. It has been discussed at several World's Poultry Congresses since the first Congress was held in 1921. About this time the International Institute of Agriculture began collecting statistics on the poultry industry, the first of which were published in the International Yearbook of Agricultural Statistics for 1923.

SCOPE OF THE WORLD'S POULTRY STATISTICS

More and more statistical material became available from the various governments until 1930 when the Institute prepared, for the Fourth World's Poultry Congress held at London, a brief outline of international poultry statistics. In the Statistics Yearbook since 1929–30, figures for a number of countries have been published regularly. In the Yearbook for 1937–38 a fairly complete series for the period from 1931 to 1937 covers about 80 countries.

These statistics are presented under the following heads:

1. Number of laying hens and egg production, and average egg production per hen.
2. Total number of fowls, geese, ducks, and turkeys.
3. Imports and exports of eggs and egg products.
4. Prices of eggs on the principal markets.

The statistics on world trade in eggs have been improved from year to year. Since 1932 the Institute has published in its Monthly Crop Report Bulletin an annual review of the world trade in eggs in the shell, with comments based on the main variations from year to year in the amount and direction of international trade. The latest of these reviews was published in the Crop Report Bulletin of June 1938, and deals with the period 1930-38.

From February 1934 the Crop Report Bulletin has also contained weekly prices of fresh eggs on the principal markets of the world. Though statistical reporting in this field is more difficult than with other kinds of livestock, and though much work has to be done in many countries to secure more complete and reliable data, the International Institute of Agriculture has noted that its efforts in this direction have yielded promising results.

At the Sixth World's Poultry Congress, held in Berlin in 1936, a resolution was passed as follows:

The World's Poultry Science Association should request the International Institute at Rome to take steps to secure the further development of the collection of statistics relating to poultry and small livestock; the delegates present should urge their respective Governments to meet the questions and requests of the International Institute of Agriculture in the interest of the whole poultry industry.

While nothing was heard from the Science Association on this resolution, the International Institute of Agriculture included the subject of poultry statistics improvement in its plans for the World Agricultural Census for 1940. The Institute also considered taking up the subject of world poultry production and trade in its new series of commodity studies, but postponed that subject for later attention in view of more urgent needs of studies on other subjects.

In the first World Agricultural Census, organized by the Institute in 1930, some statistics of poultry appeared for many of the 50-odd countries which were included in this Census. In the plans for the second World Agricultural Census, now being organized for 1940, much more complete data will be gathered, so far as available, in the various countries.

THE IMPROVEMENT OF POULTRY STATISTICS

International statistics can be no better than the *national* statistics upon which they are based. At one time this statement could have been successfully challenged because private statistical organizations using trade figures, kept the only data available on national lines. National Government statistical organizations were relatively few and weak. The governments did not use statistics so generally as the basis for policy making. Trade was relatively free and uninterrupted.

There was another strong influence against the collecting of statistics by the governments, namely, the influence of the large trade organizations that for selfish reasons did not want the general body of the producing farmers or consumers to know too much about supply and demand. It was this very clear and damaging situation for the farmers that led to the organization of the International Institute of Agriculture. In an effort to get justice for farmers the Institute was founded by those who believed that prices were determined in world markets and that accurate world-wide information would establish fair prices in the world markets.

The first step in the improvement of poultry statistics is the development of reliable and uniform methods for collecting such data in the various countries. Due to the fact that the poultry industry is so widely distributed in small units and also that the trade is confined to small areas, the facts about this class of livestock are not easily gathered, either by farm-to-farm reporting for census purposes, or by checking estimates through market reports. While it may be considered that only that part of poultry production that enters into the general trade channels is important, it is necessary to know the changes in numbers of fowls raised in order to estimate production. The short period in which birds can be matured makes it extremely difficult to get accurate data in countries where statistics are gathered only once a year. This has led to recommending certain periods of the year for making counts.

All of these problems are so well known to poultry statisticians that they need not be reviewed here. It is perhaps sufficient to point out again that international statistics can be no better than the national data upon which they are based. This leads to the conclusion that the cooperation of poultry statisticians is of paramount importance. The problem is to bring together the experts to work out good comparable methods that produce useful results. It is at this point that the International Institute of Agriculture can help.

PLANS FOR INSTITUTE POULTRY WORK

The International Institute of Agriculture is now in position to take some further steps in the improvement of poultry statistics following the general lines it has laid down for statistical advance on other subjects, such as fruit and vegetable statistics. These plans involve two particular steps:

1. A study of the methods of collecting poultry statistics now employed in the various countries must first be made by the Institute and published as a monograph. The collection of material for this study affords an opportunity for experts of all countries to comment on available data and to suggest methods of improvement.

2. A conference for poultry statisticians and other experts must then be convened by the Institute to discuss the data as presented in the monograph study, and to work out new standards to be recommended to the various countries. The more important problem of determining what type of data is of real international importance should also be discussed by this conference.

The Institute is prepared to go forward with these steps as a part of the regular program, and also to give special attention to the poultry industry in several other particulars. It is considering the preparation of a study of the World Poultry Industry, production and trade, as one of its series of studies of the principal farm commodities. This will not only cover the field of the three volumes issued in 1933 on the Poultry Industry of the World, but will also include an economic analysis of the industry as it exists in relation to general agricultural resources. More and more the Institute is striving to make its various studies fit together in a general plan which, it is hoped, will some time constitute a broad survey of the world's agricultural resources.

In the large and growing task of following the mass of new publications in the poultry industry, the World's Poultry Science Association has taken a leading part. It has not devoted particular attention, however, to statistical and economic phases of the subject, though it has included references to some publications in this field. This year the Institute has begun the publication of the "International Bibliography of Agricultural Economics," in which appear regularly references to the publications relating to the economic aspects of the poultry industry.

National legislation with particular reference to poultry industry is now appearing in many countries and these laws are reviewed at the Institute by the Legislative Section and incorporated in the Annual Yearbooks of Agricultural Legislation. These laws are summarized in a special chapter in these volumes and the original material is available in the Institute for special studies.

The technical improvements in the use of eggs as a source of special products for use in industry has also been made a subject of study by the Institute. New chemical products produced from eggs are growing in importance in many industries, thereby affording a wider market for eggs aside from their use as food. In this field of industrial uses of farm products are to be found many subjects of international importance.

The World's Poultry Congress at London in July 1930, passed a resolution asking the Institute to call a diplomatic conference on the subject of international trade in eggs. Accordingly a meeting of experts was held in May, 1931, at the Institute at Rome, and the preparatory studies were made for the convention. The diplomatic conference was held at Brussels in December 1931 and a Convention was signed by twelve countries. This Convention concerned particularly the marking for international trade of fresh and preserved eggs. Whether this agreement has worked out to the hopes of those who suggested it I cannot say, but we know that such international agreements are being called for today in several fields. At least we have in the Institute an agency that can serve at once to investigate and recommend, if any such new agreement appears desirable.

The Institute has not, as yet, organized a particular section for poultry work because the various activities heretofore mentioned fall within the scope of the principal divisions of the Institute which are—Statistical, Economic, Technical and Legislative Bureaus. When the time arrives, however, that a special unit is needed, the Institute is prepared to organize it. New sections on Horticulture and Tropical Agriculture were organized last year.

All of this new work, of course, can be developed only as rapidly as the resources of the Institute permit. More liberal support by the member countries would enable the Institute to accelerate its activities. It has at present a staff of experienced workers, now well trained in dealing with international matters, which is quite adaptable to the needs of the agricultural industries. The Institute now represents the oldest and most representative example of international collaboration under an international Convention and has demonstrated its merit over a period of one-third of a century. A large number of new international offices, bureaus, and institutions have been organized in recent years until there is a general feeling that we have altogether too many, and that we should strengthen those that now exist rather than to organize new ones.

There is no rivalry between the Institute and other international organizations, because it operates under the direct charge of its more than seventy signatory nations as the official coordinating agency in relation to all matters concerning the advancement of agriculture. The Institute is, therefore, ready to collaborate with every organization that is prepared to contribute to the agriculture of the world.

SUMMARY

The development of international statistics on the poultry industry since the first publication of such statistics by the International Institute of Agriculture at Rome in 1923 is discussed in outline. The scope of such statistics on production and trade, and in the World Agricultural Census is described. The plans of further improvement by the Institute are outlined. These plans involve a study of methods now employed in the various countries by a member of the staff of the Institute, to be followed by the International Conference of Poultry Statisticians to work out new standards to be recommended to the countries. Other work of the Institute in the form of statistical, economic, bibliographical, legislative, and technical phases of the industry are also described. Reference is made to the official position of the Institute in the holding of diplomatic Conventions, and to its functions as the representative of some seventy countries in relation to all matters concerning the advancement of agriculture.

SECTION 5.
PUBLIC SERVICE AND GENERAL

PREFACE—ADVANCING THE POULTRY INDUSTRY

By L. E. CARD, *Professor of Poultry Husbandry, University of Illinois, Urbana, Illinois, U. S. A.*

When the idea of a World's Poultry Congress was originally proposed, about a quarter of a century ago, public service to the industry consisted chiefly of undergraduate collegiate instruction in the subject, and a relatively small amount of research and experimental work. The ordinary citizen could gain little poultry information except through the monthly poultry journals, which were numerous and flourishing, or by attendance at poultry shows, which by their size, frequency, and gate receipts, clearly indicated the nature of popular interest in poultry keeping at that time.

In the United States of America we have seen extension work in poultry husbandry develop from the early years in which culling demonstrations were of first importance, to the present plan of carefully supervised projects in which leading farmers and poultrymen take an active part. Printed circulars and extension bulletins, containing specific information and recommendations on nearly all phases of poultry husbandry, are available to any citizen for the asking. Many of these are based directly on results of research at the Agricultural Experiment Stations.

Flock inspection and breed improvement programs have been developed in most of the important egg-producing countries of the world, and are being carried out with varying degrees of success by regulatory branches of government, by educational agencies, by voluntary associations of poultrymen, or by some combination of these agencies.

Market news services and statistical reports on storage holdings, hatchery operations, size of farm flocks, egg production, and farm prices of poultry products have become increasingly important and helpful as the industry has developed. Consumer education has also played a part in stabilizing the industry.

Scientific research has proved its value and has received increasing support from public funds. It has become so complex in its many branches that no individual can hope to be fully conversant with all its ramifications, nor even to understand all of its findings and applications.

Collegiate instruction has developed rapidly until there is scarcely an agricultural school or college in the world which does not offer at least one course in poultry. Advanced courses leading to the Master's and Doctor's degrees are an important part of the offerings in many institutions.

Such a development in teaching, research and extension has been quite in keeping with the fact that more farmers keep poultry than keep any other class of livestock. It is, therefore, altogether proper for a separate section of this triennial meeting of the World's Poultry Science Association to be devoted to papers grouped under the heading of Public Service and General.

FEDERAL INSPECTION OF DRESSED POULTRY FOR CONDITION AND WHOLESOMENESS

By C. E. EDMUNDS, *Supervising Inspector, Dressed Poultry Inspection, Bureau of Agricultural Economics, United States Department of Agriculture, Washington, D. C., U. S. A.*

Federal inspection of dressed poultry and edible products thereof was first inaugurated to accommodate packers and processors of canned poultry products, who felt it desirable and necessary inasmuch as such products, like other meat food products, were not acceptable in certain markets without identification of previous inspection. There is no regulatory law in the United States prohibiting the interstate shipment of uninspected poultry carcasses, poultry meat, or canned poultry products, and it is not compulsory that such products be inspected by Federal authorities. However, the health departments of a number of our larger cities have ordinances prohibiting the sale of eviscerated poultry or canned poultry products which have not been previously inspected and so identified by some authorized inspection agency acceptable to them. Federal inspection is naturally preferable and acceptable in all instances.

The Bureau of Agricultural Economics of the United States Department of Agriculture, which has authorization by an Act of Congress to inspect all perishable farm products, including inspection and certification of dressed poultry for condition and wholesomeness, is in a position to offer such inspection as may be necessary, to interested parties, through a cooperative agency. However, there is no governmental appropriation to carry on this work, and the cost of this service must be borne by the party or firms that utilize it. These costs consist of the full amounts of inspectors' salaries and additional amounts to cover administrative expenses and supervision.

The inspectors assigned to this work must have had a degree from a recognized veterinary college, and if found otherwise satisfactory they are given a period of training sufficient to acquaint them with the technique of the work. At the conclusion of this training, they are licensed as Federal dressed-poultry inspectors. The duties of an inspector are to make post-mortem inspection of every bird that is to be eviscerated and further processed in the plant to which he is assigned, and to see that the entire plant is kept in a sanitary condition at all times, that all processing is carried on under sanitary methods, that all ingredients other than poultry which have beeen included in approved formulas are of fit quality and of proper proportions, and that the finished product is labeled with only such labels as have been officially approved.

To utilize this service, a poultry eviscerating or canning plant must be of such construction as to meet the sanitary requirements of the regulations of this Bureau. This means that the walls, floors, etc., must be constructed of impervious materials which can be easily kept clean by drainage lines; there must be a sufficient number of floor-drainage inlets and drains of sufficient size, properly trapped and placed to carry off waste liquids; there must be ample natural light and sufficient artificial light for early morning or late evening operations; doors and windows must be screened; and clean dressing rooms and sanitary lavatories and toilets must be provided for all employees.

The approved equipment used for the inspection and evisceration of poultry consists principally of two electric motor-driven conveyor tables—one for inspection and the other for evisceration. The conveyors are a series of stainless steel or monel metal pans attached to a conveyor chain, and the approximate dimensions of each pan are 18 inches long, 12 inches wide, and 3½ inches deep. They are carried along the top of the table in an upright position to receive the birds and pass along underneath the table in an inverted position through a washing and sterilizing chamber.

The speed of operation of such tables depends on the class and quality of poultry to be handled. For the general run of poultry, one inspector and this equipment can handle approximately 700 birds per hour.

When poultry are received at a plant in a frozen condition, they must necessarily be defrosted to permit inspection and evisceration. This is most efficiently accomplished by immersing the poultry in water. The equipment necessary for this procedure is a sufficient number of large tanks constructed of some nonabsorbent material, preferably stainless steel. The size and number of tanks necessary are dependent on the desired production. Enough of the frozen poultry are placed in the empty tank to fill it about two-thirds full. Water is then applied, the tanks being equipped with an inflow of thermostatically controlled water at a temperature of about 90° F., and an overflow to permit the exit of cooled water from the tank as the frost is drawn from the poultry. By this method the defrosting process can be timed very accurately to supply necessary progressive operation.

Prior to the opening of the birds for inspection, pinfeathers are removed from the skin, and hair is singed from the carcass. The birds are individually placed, one in each pan of the inspection table, and as the conveyor moves along, plant employees open the abdominal and thoracic cavities, exposing all internal organs for examination by the inspector. The method of exposing the internal organs for inspection varies according to the intention of preparation for marketing. If the birds are for canning purposes, the abdominal cavity is opened wide, the thigh joints are broken down, exposing all organs in their natural position. If they are for other than canning purposes, the abdominal cavity is opened only wide enough to permit the drawing of the viscera from their cavities for examination. Broilers and frying chickens are sometimes split down the back, exposing the organs. Inspection is then made of all organs, cavities, and the entire carcass. Birds showing lesions of disease or that are otherwise unfit for consumption are condemned and removed from the table at this time. Fit and healthy birds are now ready for complete evisceration.

When the birds leave the inspection table, the head and shanks are removed and the body of the carcass passed to the eviscerating table (which is similar to the inspection table except that it has stationary dressing units on each side, equipped with sprays of running water). Here all viscera are removed, after which each carcass is conveyed to the end of the table to be immediately and thoroughly washed. These birds are now ready for further processing.

Federal inspection of dressed poultry under the supervision of the Bureau of Agricultural Economics, United States Department of Agriculture, began in the year 1928. At that time, only packers of canned-poultry products were interested in producing their various products under Federal supervision and inspection, of preparing them in accordance with officially approved formulas, and labeling them with the inspection legend of this Bureau, which reads: "Inspected and certified by Bureau of Agricultural Economics, United States Department of Agriculture." During the last 5 or 6 years, there has been a steadily growing demand by consumers in this country for Federally inspected, eviscerated, table-dressed or ready-to-cook poultry. Such poultry after inspection are prepared and packaged in numerous ways, depending on the suitability and convenience to the average consumer. For example, fowl for fricassee are cut up in proper portions for serving at the family table; broiling and frying chickens are split and portioned in appropriate parts for cooking and serving; the carcasses of roasting chickens, turkeys, ducks, and geese are left intact so that the body cavity can be filled with dressing, if desired, prior to cooking. Each bird (or its portioned parts) is then individually wrapped or packaged in such a way as to keep it in a clean and sanitary condition until it reaches the consumer. Most packers use a transparent wrapper so that the appearance and quality of the poultry can be observed when the product is offered for sale. Each packaged bird carries the brand and name of the packer, as well as the net weight and identification that it is a Federally inspected product.

The packaging of eviscerated poultry, of course, is done during the season in which poultry are most abundant. To prevent spoilage and to preserve the natural flavor until the season of scarcity and a favorable marketing time, the product must be quickly and thoroughly frozen and held in that condition until it reaches the consumer. Various methods of freezing are used. The principal factor, regardless of the method employed, is that of extremely low temperatures. Favorable results are obtained by temperatures of from $-15°$ to $-50°$ F. The temperature of the holding rooms for carrying the poultry for long periods should not be higher than 0° and preferably $-20°$ F., as the colder temperatures definitely prevent dehydration, commonly called freezer burn.

There is no difference in the methods employed in the actual inspection, whether the dressed poultry are to be prepared as a canned-poultry product or eviscerated and marketed in a frozen condition. All the internal organs are observed and handled to detect any disease and the internal cavities, as well as the external part of the bird, are examined.

During a representative month in the flush season of poultry last year, there were inspected in the United States 6,581,271 pounds, which included the various classes and grades of poultry. Of this amount, 115,486 pounds were condemned for various reasons as being unfit for food. These condemnations may be classified as follows: For avian tuberculosis, 59.6 percent; for leukemia, abscesses, peritonitis, and external appearance, 12.7 percent; for decomposition, 11.5 percent; for septicemia, 9.9 percent; for tumors of various kinds, 4.7 percent; for bruises, 0.9 percent; and for emaciation, 0.7 percent. Almost 60 percent of the condemnations were for avian tuberculosis, and this disease is by far the most important to be considered in the postmortem inspection of poultry. A great variation in the extent of this disease is noted, depending on the age and sex of the birds. In young birds we find few lesions of this disease. Apparently it does not become active enough to be detected to any great extent until the birds are approximately 1 year of age. As they become older, the disease seems to be more progressive. Condemnation on account of avian tuberculosis in top-quality broiling and frying chickens is almost negligible; in top-quality roasting chickens it is about 0.1 percent; in top-quality fowl, about 0.7 percent; in old fowl, which would be classed as No. 2 grade, from 2 to 10 percent or more, according to quality; in old cocks approximately 1 to 2½ percent, depending on quality. From this classification it will be seen that the disease is apparently more prevalent in the female than in the male. This condition may be attributed to the general habits of the two sexes. It is a natural instinct of the female to do more scratching and picking than is customary with the male, thereby increasing the possibility of her becoming infected.

It is our experience that tuberculosis is found in the spleen and liver more often than in any of the other organs. Often the spleen alone is affected, but in most instances the spleen, liver, and intestines are involved. Very rarely do we find tuberculous lesions in the lungs or respiratory organs even in the most generalized cases. In well-fleshed birds, as a rule the lesions are not found in organs other than the spleen and liver, whereas in birds of poorer quality the lesions are quite extensive in the spleen, liver, and intestines, and the poorer the quality, the more abundant the lesions.

Poultry which have been condemned as unfit for food are disposed of by treating with denaturing oil or crude carbolic acid, after which they may be rendered in inedible tanks. In some instances they are destroyed by incineration.

In the calendar year of 1938, there were inspected in the United States 43,538,661 pounds of poultry of various grades and classes, of which 42,744,696 pounds were certified as being fit for food, and 793,965 pounds, or 1.9 percent, were condemned as inedible poultry.

The canned-poultry industry in this country is one of vast proportions, and practically all prominent canned-poultry packers are now utilizing the Federal inspection service. Great quantities of poultry are processed to produce a variety of products, known as chicken soups, whole and half chicken in gelatin, egg noodle and chicken dinner, egg noodle and giblet dinner, chicken a la king, deviled chicken, creamed chicken, chicken hash, boned chicken, chicken a la Creole, potted chicken, chicken stew with vegetables, chicken breasts with sauce, chicken tamales in sauce, salad chicken, chicken pot pie, chicken liver pâté, chicken liver soup for babies, sliced turkey with gravy, etc. Edible byproducts are used so far as is practical to produce some of the above-named products. Excess fat is rendered and added to strengthen soups, and in some instances the shanks of the older birds are processed to produce soup stock.

The volume of canned-poultry products consumed in this country has increased considerably since the inauguration of Federal inspection. It is, therefore, reasonable to assume that if all processed poultry were inspected, eviscerated, and sealed in a sanitary package at the time of slaughter, there would result an increased consumption of poultry. It is the belief of many of the present packers of eviscerated poultry that in the near future a much greater proportion of poultry will be marketed as a ready-to-cook, Government-inspected product. There are economic factors to support this belief. Poultry is a seasonal product and, therefore, excess stocks must be stored under refrigeration from the season of plenty to the season of scarcity.

As with other meat products, there seems to be no good reason for holding in a refrigerating plant dressed poultry which have not been eviscerated. The costs of transportation and storage are computed on a weight basis, and therefore there would be a saving of approximately 25 percent for this service. The possibilities of contamination and destruction of the natural flavor of the meat are considerably lessened if poultry are Federally inspected and eviscerated before storage.

Consumers are rapidly becoming aware of the advantages of purchasing fully eviscerated and Government-inspected poultry. There can be no question as to its being desirable from the standpoint of convenience in further preparation in the home, as well as the assurance it affords of the purity and wholesomeness of the product. This increased confidence on the part of the consumer will in all probability result in greater consumption of poultry. Naturally, this is of direct benefit to the producer for two reasons. First, it will encourage the production of a more healthful and better quality product, and, second, there will be an increased demand.

SUMMARY

The dressed-poultry inspection service, conducted by the Bureau of Agricultural Economics, United States Department of Agriculture, is financed by the firms which use it. It is not compulsory. Inspectors assigned to this work are graduates of recognized veterinary colleges. Their duties are to make post-mortem inspections and to supervise the sanitary conditions under which poultry are prepared and processed, and labeled as an inspected product.

To use this service, a poultry eviscerating or a poultry canning plant must be of such construction as to meet the sanitary requirements of the regulations of this Bureau, and the equipment must be approved by this Bureau so far as efficiency and sanitation are concerned.

Poultry that are to be offered for inspection must be in such condition as to permit the opening of the carcasses for free examination of all internal organs. Different methods of exposing internal organs are used for different classes of poultry, depending on the way that the poultry will be finally marketed.

Causes for condemnation of poultry as being unfit for food are numerous, but the principal cause is avian tuberculosis.

Canned poultry products are prepared and processed in several ways. Byproducts of poultry in some instances are important in the preparation of canned poultry products.

This inspection service is advantageous to the consumer as well as to packers, processors, and producers. It assures consumers that they may safely buy and use the inspected product. It enables packers and processors to prepare a more healthful and better quality product. It benefits producers through increased consumption of the inspected products.

AUFBAU UND ERFOLGE DES GEFLÜGELGESUNDHEITSDIENSTES IN DEUTSCHLAND

Von DR. F. WEISGERBER, *Verwaltungsamt des Reichsbauernführers, Berlin, Deutschland*

Der Geflügelgesundheitsdienst in Deutschland fußt auf einer Reichsmaßnahme, die durch Verbilligung des Bezuges von Küken, Junghennen und Hähnen für den Bauern durch Mittel des Reiches allmählich dazu führen soll, daß in unseren bäuerlichen Geflügelhaltungen in Zukunft nur noch Leistungstiere zur Verwendung kommen, die das Futter, das sie erhalten, auch lohnen. Es ist nun klar, daß man bei der sich daraus ergebenden Verteilung einer riesigen Zahl von Jungtieren aus verhältnismässig wenig Zuchten auf sehr zahlreiche bäuerliche Betriebe und bei der sich daraus ebenfalls ergebenden Einengung der Abstammung der Tiere auch in den bäuerlichen Geflügelhaltungen besonders darauf achten muss, möglichst nur gesunde Tiere aus gesunden Beständen zur Verteilung zu bringen.

Der Geflügelgesundheitsdienst bezweckt daher eine Gesundheitskontrolle der Herdbuch- und Vermehrungszuchten, welche die Aufgabe haben, die bäuerlichen Geflügelhaltungen mit solchen Leistungstieren zu versehen. Er wurde im Jahre 1936 eingeführt und steht somit im dritten Jahre seiner Entwicklung und Wirksamkeit. Z. Zt. unterliegen ihm über 1.200 Herdbuch- und Vermehrungszuchten, d. h. alle Zuchten, die in Deutschland als Herdbuch- und Vermehrungszuchten anerkannt sind, und für deren Küken und Junghennenlieferungen der Bauer daher aus Reichsmitteln den Zuschuß erhält. Sie umfassten im Jahre 1938 im Durchschnitt 732.000 zur Zucht benutzte erwachsene Hühner, doch wird diese Zahl mit den Herdbuch- und Vermehrungszuchten aus dem Lande Oesterreich und dem Sudetengau sowie den hinzukommenden Bruteierlieferbetrieben im laufenden Jahre auf etwa 1.200.000 Tiere anschwellen, die jährlich durch den Geflügelgesundheitsdienst überwacht werden müssen.

Die Leitung des Geflügelgesundheitsdienstes liegt in der Hand von 22 über das ganze Reich verteilten tierärztlichen Instituten, die mit der Wahrnehmung des Gesundheitsdienstes in den Beständen meist einen spezialistisch vorgebildeten Institutstierarzt, mitunter praktische Tierärzte betrauen.

Der Zweck des Untersuchungsdienstes ist, wie bereits erwähnt, der, die bäuerlichen Betriebe vor der Einschleppung von Krankheiten zu schützen. Das geschieht durch verschiedene Maßnahmen. Zunächst werden die Lieferbestände jährlich der stichprobenweisen Blutuntersuchung auf Pulloruminfektion unterworfen. Heute wird dabei meist die Schnellagglutination angewandt, die gegenüber der Langsamagglutination den Vorteil hat, daß das Ergebnis gleich auf der Hand liegt und infolgedessen auch der Züchter selbst die Blutreaktion erkennen kann. Daraus ergibt sich der weitere Vorteil, daß nun den positiven Tieren sofort der Schwanz gestutzt und der Geflügelring entfernt werden kann, sodaß eine bessere Kontrolle darüber besteht, daß diese Tiere auch schleunigst aus dem Bestande entfernt und nicht anders wohin als Zuchttiere verkauft werden. Schließlich hat sie noch den Vorteil, daß die Methode billiger durchzuführen ist und das Institut nicht mit unnötiger Arbeit durch Blutuntersuchungen belastet. Wo allerdings ein eingearbeiteter und spezialistisch vorgebildeter Tierarzt nicht zur Verfügung steht, wird auf die Blutentnahme in Röhrchen und die Durchführung der Langsamagglutination im Institut zurückgegriffen. In diesem Falle ist der Züchter verpflichtet dem Institut nach Übermittelung des Ergebnisses die Fußringe der positiven Tiere einzusenden.

Gelegentlich der Blutuntersuchung durch den Tierarzt werden die Tiere auch auf andere klinische Krankheitserscheinungen z.B. Augenveränderungen und Lahmheiten infolge Marek'scher Hühnerlähme untersucht und alle klinisch verdächtigen Tiere entfernt. Auch hat sich der Tierarzt dabei um die Hygiene in Haltung und Fütterung zu kümmern und den Züchter auch in dieser Richtung zu beraten.

Über den Befund ist ein vorgedruckter Befundschein auszufüllen, der dem Züchter ausgehändigt wird, aber in Durchschrift auch dem leitenden Institut wie der zentralen Leitung des Geflügelgesundheitsdienstes zugeht, sodaß auch an diesen Stellen eine Übersicht über die Gesundheit der Bestände und über etwaige Mängel in Bezug auf Haltung und Fütterung vorliegt.

Weiterhin ist jeder angeschlossene Bestand verpflichtet sämtliche gestorbenen Tiere dem zuständigen Untersuchungsinstitut zur Feststellung der Todesursache einzusenden. Der Besitzer erhält dann vom Institut eine entsprechende Benachrichtigung und bei Feststellung einer Seuche oder seuchenartigen Erkrankung entsprechende schriftliche Beratung, was er zur Beseitigung der Seuche tun muß.

Da diese Betriebe regelmässig auch durch die Geflügelzuchtberater, die über den Gesundheitszustand im Betriebe unterrichtet sind, sowie einmal jährlich ausserdem durch den Anerkennungsausschuß ländlicher Geflügelzüchter, dessen Mitglied der tierärztliche Leiter des Geflügelgesundheitsdienstes bezw. der die Untersuchungen durchführende Tierarzt ist, gelegentlich der Hähnekörung aufgesucht werden, ist eine ständige Kontrolle der Bestände auch in gesundheitlicher Richtung, insbesondere in Bezug auf die Durchführung vorgeschlagener Bekämpfungsmaßnahmen von Seuchen gewährleistet.

Wird in einem Bestande eine Seuche in stärkerer Ausbreitung festgestellt, sodaß es nicht möglich erscheint, sie in kürzerer Frist zu tilgen oder zur Bedeutungslosigkeit herabzudrücken, so werden durch den Anerkennungsausschuß auf Vorschlag des Leiters des Geflügelgesundheitsdienstes je nach dem Wesen und der Bedeutung der Seuche Verkaufssperren für Hähne, für Küken und Junghennen usw. zunächst für die Dauer einer Brutperiode verhängt.

Um über diese Maßnahmen hinaus den Käufer vor der Einschleppung von Seuchen durch Ankaufstiere zu schützen, hat dieser das Recht bei Todesfällen unter den Ankaufstieren die Tierleichen zur kostenlosen Untersuchung an das zuständige Institut zur Feststellung der Todesursache einzusenden. Wird hier einwandfrei festgestellt, daß eine Einschleppung der Erkrankung aus dem Lieferbetriebe vorliegt, so kann der Käufer diesen regresspflichtig machen. Der Lieferbetrieb ist verpflichtet, durch Aushängeschilder und kleine grüne Zettel, welche auf die Rechnung für die gelieferten Tiere zu kleben sind, und in denen auf die Möglichkeit der kostenlosen Untersuchung unter Angabe der Adresse des Untersuchungsinstitutes hingewiesen wird, den Käufer darauf aufmerksam zu machen.

So ist durch die Maßnahmen des Geflügelgesundheitsdienstes die Möglichkeit sowohl für die Herdbuch- und Vermehrungszuchten wie für die Bruteierlieferbetriebe gegeben, ihren Bestand von Seuchen und seuchenartigen Erkrankungen frei zu halten bezw. zu säubern und andererseits dadurch die Möglichkeit geschaffen, den Bauern vor Übervorteilung durch Lieferung von kranken und daher minderwertigen Tieren zu schützen.

Im Vordergrund der Bekämpfung von Seuchen steht, wie in den meisten Kulturländern, die der Pullorumseuche. Unter den 8.464 im Jahre 1938 im Geflügelgesundheitsdienst zur Feststellung der Todesursache eingesandten Küken wurde sie bei 28.3 Prozent als Todesursache ermittelt. Zu ihrer Feststellung in den überwachten Beständen wurde bei 443.886 Zuchthühnern die Blutuntersuchung durchgeführt und dabei bei 21.215 = 4,8 Prozent der blutuntersuchten Tiere eine positive Reaktion ermittelt.

Eine Massnahme wie der Geflügelgesundheitsdienst bedarf selbstverständlich mehrerer Jahre Anlaufzeit, ehe er sich einführt und besonders ehe seine Bestimmungen von den Beteiligten als zu ihrem Vorteil vorhanden erkannt und willig durchgeführt werden. Aber gerade bei derartigen Maßnahmen ist selbstverständlich die Mithilfe und die vertrauensvolle Zusammenarbeit mit dem Züchter von ausschlaggebender Bedeutung. Daher kann man in den ersten Jahren des Anlaufens noch keine überragenden Erfolge von einer solchen Maßnahme verlangen. Trotzdem können sich die Erfolge der ersten beiden Jahre der Pullorumbekämpfung schon sehen lassen. Während nämlich die stichprobenweisen Blutuntersuchungen im Jahre 1937 ergaben, daß 33,8 Prozent der überwachten Bestände frei von pulloruminfizierten Tieren waren, und daß 6,5 Prozent der Bestände eine bis 1 prozentige und 59,7 Prozent eine mehr als 1 prozentige Verseuchung aufwiesen, hat die Blutuntersuchung des Jahres 1938 ergeben, daß nunmehr bereits 41,8 Prozent der überwachten Bestände frei waren und 11,2 Prozent eine bis 1 prozentige und nur noch 47 Prozent eine mehr als 1 prozentige Verseuchung zeigten.

Bisher wurden die Bestände einer 10 prozentigen stichprobenweisen Blutuntersuchung unterworfen und nur bei einer höheren Verseuchung die Untersuchung des Gesamtbestandes angeordnet. Für das Jahr 1939 ist nun eine erhebliche Verschärfung dieser Bestimmung getroffen worden.

Grundsätzlich sind in diesem Jahre bei der stichprobenweisen Untersuchung 25 Prozent der Tiere zu untersuchen, wo sich hierbei auch ein positiver Fall ergibt, ist anschließend der gesamte Bestand zu untersuchen. Der Anerkennungsausschuss ländlicher Geflügelzüchter wird seine Reisen so einrichten, daß er die Bestände regelmässig erst nach Vorliegen des Ergebnisses der Blutuntersuchungen aufsucht, um nachzukontrollieren, ob die als infiziert erkannten Tiere auch tatsächlich alle entfernt worden sind.

Um bei der Durchführung des Geflügelgesundheitsdienstes auch den wirtschaftlichen Vorteil als Anregung zu benutzen, haben Bestände, welche infolge Verseuchung die Gesamtuntersuchung durchführen lassen müssen, zu den Kosten der Untersuchung der restlichen 75 Prozent in diesem Jahr 5 RPfg je Tier beizusteugern, während im übrigen die Kosten aus Reichsmitteln getragen werden. Im kommenden Jahr ist beabsichtigt, diesen Satz zu erhöhen und übernächstes Jahr solche Züchter die Gesamtkosten der Blutuntersuchung der 75 Prozent tragen zu lassen, sodaß jeder Züchter schon aus wirtschaftlichen Erwägungen heraus danach streben muss, seinen Bestand so schnell wie möglich von verseuchten Tieren zu befreien.

Nach Ablauf von fünf Jahren sollen alle Betriebe, die bis dahin nicht restlos frei von weisser Kükenruhr sind, als Herdbuchzuchten, Vermehrungszuchten oder Bruteierlieferbetriebe aberkannt werden. Dagegen werden Tiere aus pullorumfreien Beständen schon jetzt bei der Bewertung, bei der Körung oder auf Ausstellungen einen Zuschlag in der Punktzahl erhalten, sodaß sie von vornherein besser gestellt werden, als Tiere aus nicht pullorumfreien Beständen.

Zweifellos dürften uns diese Massnahmen, für deren Durchführung sich alle beteiligten Stellen mit Energie einsetzen werden, in wenigen Jahren eine Reinigung unserer Zuchtbestände von der Pullorumseuche bringen.

Zu den Ergebnissen der Feststellung der Todesursachen bei den zur Sektion eingesandten erwachsenen Hühnern ist folgendes zu sagen: Im ganzen kamen 12.552 erwachsene Hühner zur Sektion, das bedeutet bei einem Durchschnitt von 732.471 erwachsenen Hühnern, die in den Zuchten gehalten wurden, 1,71 Prozent. Auch wenn man in Rechnung setzt, daß ein nicht unerheblicher Teil der erkrankten Hühner durch das Schlachtmesser dem Sektionstische entzogen wird, so dürften im ganzen gesehen, die Verluste durchaus erträglich sein.

Bei diesen Verlusten stehen bei weitem im Vordergrund die unspezifischen Urogenital-Erkrankungen, also die eigentlichen Berufserkrankungen unserer Hühner, die 21,7 Prozent der zur Sektion gekommenen Hühner oder 0,37 Prozent der überwachten Hühner ausmacht. Dennoch erscheint diese Zahl, die ja ein guter Gradmesser sowohl für die Gesamtkonstitution wie für die Konstitution der Legeorgane ist, gemessen an der heutigen durchschnittlichen Leistung unserer Hennen aus den Vermehrungszuchten ausserordentlich günstig.

Weniger erfreulich ist der Ausweis der Statistik in Bezug auf die nicht infektiöse Leukose, die mit 13,8 Prozent als nächst höchste Verlustzahl erscheint, da uns z. Zt. ein Weg zu ihrer Bekämpfung fehlt, denn die Abschlachtung der erkrankten

Tiere, wie wir sie heute betreiben, ist natürlich keine Bekämpfung, weil eine Vorbeuge in ihr nur in sehr begrenztem Maße gegeben ist.

Die Entoparasiten stehen mit 9,5 Prozent zu Buche. Diese im Verhältnis hohe Zahl ist eine Folge des Lebens der Tiere auf engem Raum. Z. ZT. werden auf unsere Veranlassung in mehreren Instituten Versuche in Bezug auf ein möglichst wirksames und unschädliches Mittel zur Abtreibung der Darmparasiten durchgeführt, die sich erfolgreich anlassen.

Der Anteil der Visceral-Gicht an den Verlusten ist mit 85 Prozent verhältnismässig hoch. Neben der Unmöglichkeit, die Eiweißzufuhr nach Konstitution und Leistung inviduell einzurichten, ist sie eine Folge der Haltung der Tiere auf engem Raum und muß als solche in den Kauf genommen werden.

Die Marek'sche Lähme wurde bei 5,4 Prozent der Sektionen festgestellt. Von fast allen Stellen wird übereinstimmend berichtet, daß sich die Lähme durch vollkommene Isolierung der gesunden Nachzucht erfolgreich bekämpfen läßt, doch scheint die Vererbung der Empfänglichkeit bei der Einschleppung sowie bei der Ausbreitung der Seuche im Bestande eine gewisse Rolle zu spielen.

Z. ZT. befindet sich ein Merkblatt mit guten farbigen Abbildungen der Augenveränderungen in Arbeit, das dann dem Züchter bei der rechtzeitigen Erkennung der lähmeverdächtigen Tieren dienen und helfen soll, die Bestände von der Marek'schen Lähme zu befreien, denn gerade bei der Bekämpfung dieser sich so versteckt entwickelnden Seuche kann die intensive Mitarbeit des Züchters nicht entbehrt werden.

Die übrigen Seuchen und seuchenartigen Erkrankungen wie die Pockendiphtherie mit 1,4 Prozent, die Tuberkulose mit 1,4 Prozent, die Cholera mit 0,2 Prozent, Avitaminose mit 0,9 Prozent usw. spielen eine untergeordnete Rolle; sodass ohne Frage festzustellen ist, daß der Gesundheitszustand unserer Geflügelzuchten als gut zu bezeichnen ist.

ZUSAMMENFASSUNG

Der Geflügelgesundheitsdienst stellt eine Maßnahme zum Schutze der von den Herdbuch- und Vermehrungszuchten mit Küken, Junghennen und Hähnen belieferten bäuerlichen Betriebe dar.

Die Leitung des Geflügelgesundheitsdienstes liegt in den Händen von 22 über das Reich verteilten Instituten. Er umfaßt z. Zt bereits über 1.200 solcher Betriebe mit rund 732.000 erwachsenen Zuchthennen. Im laufenden Jahr wird die Zahl der kontrollierten Tiere durch das Hinzutreten von weiteren Betrieben, insbesondere Bruteierlieferbetrieben auf etwa 1.200.000 anschwellen.

Diese wurden bisher jährlich der 10 prozentigen stichprobenweisen Blutuntersuchung auf Pulloruminfektion untersucht. Bei stärkerer Verseuchung mußte der Gesamtbestand untersucht werden. In Zukunft werden alle Bestände der 25 prozentigen stichprobenweisen Blutuntersuchung und bei auch nur einem positiven Befund der ganze Bestand der Gesamtblutuntersuchung unterworfen. Die Schnellagglutination ist dabei die Methode der Wahl.

Im Jahre 1938 wurden bei 443.886 Tieren Blutuntersuchung durchgeführt und bei 4,8 Prozent eine positive Reaktion ermittelt. Die Blutuntersuchung hat ergeben, daß z. Zt. 41.8 Prozent der Bestände vollkommen frei von weisser Kükenruhr sind, daß 11,2 Prozent eine bis 1 prozentige und 47 Prozent eine über 1 Prozent Verseuchung aufweisen. Das bedeutet gegenüber dem Vorjahre einen erheblichen Fortschrift. Die neuen Maßnahmen für das Jahr 1939 lassen weitere bedeutsame Erfolge erhoffen.

In den mit der Leitung betrauten Instituten wurden im Jahre 1938 außerdem 12.552 erwachsene Hühner und 8.464 Küken aus angeschlossenen Beständen zerlegt. Gewisse Bedenken in Bezug auf ihre Ausbreitung läßt dabei nur die nicht infektiöse Leukose aufkommen, die 13,8 Prozent der zerlegten erwachsenen Hühner betraf. Sonst ist der Gesundheitszustand unserer Zuchten als gut zu bezeichnen.

SUMMARY

The poultry health service is a measure for the protection of those agricultural poultry keepers who are buying their breeding stock from breeding stations of the Reich Poultry Pedigree Register and from stations for the production of breeding stock.

The direction of the poultry health service lies in the hands of 22 veterinary institutes all over the Reich. At the present time it controls the state of health of the poultry of over 1,200 stations, with a total of about 732,000 adult breeding hens. During the current year, this figure will be further increased through the addition of other stations, especially of stations for the production of hatching eggs.

Blood tests for pullorum disease were made at random on 10 percent of the poultry of those stations which are under the supervision of the poultry health service. When a large number of birds were found to be diseased, the entire flock had to be examined. In the future, 25 percent of the birds of the flock will be subjected to the blood test, and even in the case of one positive reaction, the entire flock will be tested. For this, the rapid whole-blood test is the method mostly preferred.

During 1938, 443,886 blood tests were made, and in 4.8 percent of the cases the reactions were positive. The blood tests showed that at

the present time 41.8 percent of the flocks are entirely free from the white diarrhea of chicks, that 11.2 percent of the flocks are diseased up to 1 percent, and 47 percent above 1 percent. This indicates a considerable progress in comparison with the preceding year. Further important results may be expected from the new measures for 1939.

In the institutes entrusted with the sanitary control, 12,552 adult hens and 8,464 chicks from supervised flocks were dissected. Certain apprehensions regarding further spreading arose only in the case of the noninfectious leucosis with which 13.8 percent of the dissected hens were affected. Otherwise the state of health of our breeding stock may generally be regarded as good.

GOVERNMENTAL PROCEEDINGS FOR THE IMPROVEMENT OF POULTRY BREEDING IN HUNGARY

By DR. ARTHUR HORN, *Secretary of the National Agricultural Society of Hungary, Budapest, Hungary*

Poultry breeding in Hungary is of considerable importance because it not only furnishes a large part of the income of the small farmer, but also plays an important role in the nutrition of the people.

In order to show the great economical importance of poultry breeding in Hungary, I must first mention some data about the Hungarian poultry exports, which are mainly to England, Germany, and Switzerland.

During the first few years following the Great War, there was a big slump in poultry breeding in Hungary. However, 1920 was a year of prosperity, which was so great that the poultry exports of the years following were practically equal to those of prewar Hungary, which included about three times as much territory as that after 1920. In 1927, the value of Hungarian poultry exports was 89,000,000 pengös (about $25,000,000). In the following years there was some decrease, and the exports of 1937 amounted to only 55,500,000 pengös (about $16,000,000). However, the decrease was also due to lower prices. By comparing the value of exported cattle—about 55,000,000 pengös—and pigs—about 46,000,000 pengös—the importance of poultry breeding in Hungary is clearly shown.

The approximate numbers of poultry kept in Hungary were, according to the last statistics, as follows: 41,500,000 chickens, 6,500,000 geese, 1,200,000 turkeys, and 4,500,000 ducks. These figures show the importance of poultry breeding in Hungary, considering that the human population was about 9,000,000. Today, after the Hungarian regions of Czechoslovakia have been rejoined to Hungary, the population is about 10,000,000, and the number of poultry has increased accordingly.

Most of the poultry keeping in Hungary, perhaps 95 percent, is done by small holders under rather extensive conditions; but during the years of prosperity, a great number of poultry farms had been established, partly with governmental subsidies. As long as the market prices of poultry products and of the stock birds, as well as the feeding materials, were favorable for the breeders, these strictly poultry farms were able to obtain fair profits. When, however, the world's agricultural crisis showed its first signs in Hungary, the renting of these farms could not be kept up. Another reason for this is the fact that all necessary grain feed has to be purchased by the farmers, even to a larger extent than in western European countries, as the grass crops, owing to the climate of Hungary, are seasonally very limited; hence, the cost of feeeding is proportionally too high. There is a likelihood, however, that middle and large farmers will now go into poultry keeping more extensively than in the past, as they intend thereby to utilize grains and other feedstuffs remaining on the fields after the various crops.

The condition and the working systems of the small farmers in Hungary are more suitable for poultry keeping than those of most other European countries. The "tanya system," a typical Hungarian small farming system, lends itself par excellence to poultry breeding. In Hungary, a great number of small farmers, especially in the poultry-breeding areas, live on "tanyas," that is, in their own houses, situated on their own land and, in consequence, the agricultural buildings are distant from one another. Therefore, the poultry have a vast territory, where they can move about freely, with the result that their rearing cost is comparatively small. Another advantage of importance is that the different flocks are more or less isolated and not so much exposed to infections. Hungarian poultry keeping, all around, is based on the utilization of all waste of grains, etc., of the fields and of the household.

The Hungarian Government, realizing in good time the great importance of poultry breeding, took new steps to raise its standard. More than half the budget for animal breeding, except horse breeding, is used for the improvement of poultry breeding. As the strictly poultry farms in Hungary were not competitive on the various markets, yet for purposes of selection as well as supplying good stock to the country it is important that a sufficient number of farms should exist, means had to be found to insure their prosperity.

For this purpose, a selection was made of farms which had already reached a certain standard—trap-nesting the birds, keeping records, etc, and disposing of all laying hens that do not produce a minimum of 200 eggs. At present there are about 250 such farms, which are now all under official veterinary control for pullorum disease and most of them for tuberculosis. The Government will not take eggs or cockerels from farms where the infection of the stock with pullorum disease exceeds 2 percent.

To insure that breeding work is conducted on the officially controlled farms, each such farmer must send on October 1, 1939, a certain percentage of pullets to the national laying trials, in accordance with the number of birds kept by him. In case some birds do not show an acceptable performance, the farms from which they originated will be excluded from the list of Government suppliers for a certain time.

The Government subsidy to the officially controlled farms ensues in two ways: Through the incubating centers and a cockerel scheme. At present there are 8 incubating centers in Hungary, each center having incubators holding from 25,000 to 30,000 eggs. The day-old chicks are sold to farmers on very convenient terms and at low prices varying with the season, the highest being in December, January, and February. The Government pays the difference between the cost of production and the amount received by the sale of the day-old chicks. The centers buy eggs exclusively from controlled farms and pay for these from 30 to 60 percent above the ordinary market egg price. The number of eggs at present required by the centers is about one million per year. As the farms are paid a better price, as already stated, for a large number of eggs produced by them, they thus obtain a certain help from the Government through the incubating centers.

The object of these incubating centers is not only to distribute more valuable strains and breeds throughout the country, but also to increase the number of early hatched table chickens, ready to be sold in March and April.

Rearing of these chickens is done not only by the farmers but also by a certain class of country workmen who are not fully occupied during the winter, the rearing thus paving the way for a new winter-house industry.

Another Government action is the cockerel scheme, which also has for its final object the improvement of the poultry stock. By this scheme a great number of cockerels are yearly carefully selected from the stocks of the controlled farms and purchased at prices varying from 100 to 300 percent above the price of ordinary chickens sold for meat. Such well-chosen cockerels are distributed to reliable small holders—10 to 13 thousand per year—at a price less than that of the ordinary price of cockerels sold for meat.

A rather important question in Hungary is that of the breeds. It has already been stated that poultry in Hungary is kept under rather extensive conditions. In order to assure selling possibilities for Hungarian poultry in the various markets, the poultry must be offered at competitive prices and for this reason Hungarian poultry must be kept and fed as economically as possible. The different heavy breeds are not adaptable to Hungarian conditions, as the climate of the country influences their alertness to such an extent that they are no longer able to obtain their feed from the fields, and consequently cannot make use of the so-called absolute feeding materials.

The most popular breed is the Rhode Island Red, which is used a great deal for cross-breeding with the various Hungarian breeds. The disadvantages of this breed, however, from the point of view of Hungarian breeding conditions, are mainly the insufficient alertness and the poor feathering capacity. The otherwise excellent Leghorn breed is not so well suited for Hungary as its meat is not appreciated and it lacks the characteristic of broodiness, which is important for the small farmer.

Our native hen is the so-called Hungarian hen, specimens of which are shown at the Live Bird Exhibit. Four varieties of this hen are bred, viz, the barred, the white, the yellow, and the partridge colored. This breed furnishes a very tasty but not too heavy table bird. The big breast is especially remarkable. The Hungarian hen is very hardy and gathers its feed from very early in the spring until very late in the autumn, is quick growing, and quick feathering. Its egg production, however, has not yet developed to an entirely satisfactory standard. Hungarian chickens and eggs are exported to a number of European countries, and several of them are rather particular about the color of the bird and the eggs. In order to make purchases for the merchants easier, in other words, to enable them to select from a relatively small territory, it has been decided to establish different uniform breeding areas where only one variety of Hungarian fowl is kept—for instance, yellow- and partridge-colored fowl in Transdanubia, barred fowl in Upper-Hungary, and white fowl on the Plain of Hungary (fig. 1). These breeding areas are not yet completed, and it will be some time before they will be fully established.

In order to facilitate the quick development of these breeding areas, all controlled farms must breed a given number of Hungarian fowl of the variety required from its respective district. These controlled farms must supply a large number of eggs to the incubating centers, so as to enable them to provide the respective day-old chicks to the respective districts. The same requirement applies in the cockerel scheme.

At present, about 45 percent of the output of the incubating centers belongs to the Hungarian breed; the remaining, to crosses with Leghorns and Rhode Island Reds.

Other lines of poultry breeding of importance for Hungary are goose, turkey, and duck breeding. The goose is the typical large bird of the small farmer, such as the tanya farmer and also of the man raising poultry on small plots in the villages. The geese of a village or a part of a village gather together early in the morning and go out in groups, often of many hundreds, to the pastures for grazing and come back before sunset. The Hungarian goose is relatively small, with very good fattening and liver-developing ability. It lays about 20 to 40 eggs per year and is never monogamous. One gander fertilizes the eggs of 4 or 5 females. Feathers and geese livers are good export articles of Hungary. Turkeys, which are exported from Hungary chiefly before Christmas and especially to England, are kept by small, and also by larger farmers. The breed mostly kept in Hungary is the Bronze turkey; the White Mexican is bred only to a very limited extent. Hungarian turkeys are of medium size.

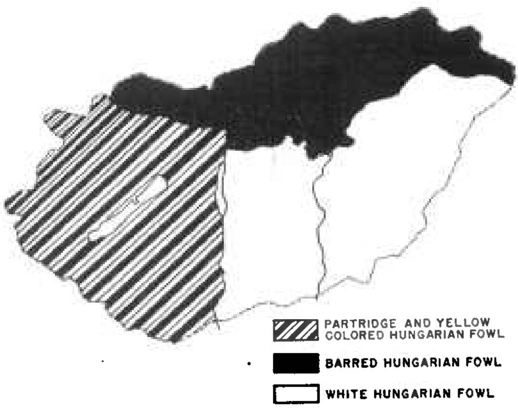

FIGURE 1.—Poultry breeding areas in Hungary.

Changes in selection are now being brought about, as in the past, in order to obtain a good yearly performance, uniform egg color and shape, as well as the desired weight. The question of constitution has been neglected. The commercial farmers in general culled the birds when they reached a certain age. This system, however, did not enable them to select those individuals which might have shown a high performance for an extended period. The lack of good constitution in highly selected breeds is also due to the fact that very often individuals which should have been culled have been used in breeding, because of their good descendants. Another reason for the weak constitution of highly selected breeds is, that on modern farms the birds are kept under favorable conditions and are not exposed to various infections; consequently, it is not possible to pick out the strains having considerable resistance against various diseases and constitutional defects. The lack of good constitution of the highly selected breeds is especially noticeable when they are placed under the conditions of the small holders. As the main object of the controlled farms is to provide the small holders with the best and most suitable strains, the question of constitution is of utmost importance.

It is practically impossible to tell by the appearance the constitution of a bird. Yet there is one indication of good constitution and that is longevity. Undoubtedly good performance for an extended period is in positive correlation with longevity. It is known that the keeping of old hens has some disadvantages: The yearling hens are the good winter layers, old hens are more likely to be disease carriers, etc. Yet the advantages for general breeding are far greater by selecting for longevity. The amortization of the cost of the bird is more favorable if it can be made over a longer producing period, but this is not so important as the fact that birds of good constitution are resistant to the various infections. Furthermore, their offspring will be healthier, easier to rear, and more economical to keep. These qualities are especially to be taken into consideration for countries like Hungary, where the greater part of poultry breeding is in the hands of small farmers. Therefore, in our breeding the tendency is to select strains with a performance of 500 to 700 eggs during a laying period of about 3 years.

The Animal Breeding Department of the Royal Hungarian Ministry of Agriculture and the numerous societies endeavor to improve poultry breeding to their best ability, and hence there is no doubt that its standing days will gradually improve. This improvement is also greatly supported by the different experiment stations—Gödöllö, Pápa, Kecskemét, etc.—and by the intensively organized special schools and local poultry-breeding courses.

SUMMARY

The rather difficult poultry-producing conditions of Hungary, which are due to the influence of the continental climate, to the methods of poultry keeping, and to local economic conditions, allow the keeping of certain types of poultry only. Therefore, a special system of governmental proceedings had to be established in order to further the improvement of the standard of poultry keeping in Hungary.

An account is given of the great importance of poultry breeding in the economic life of Hungary and its exports.

About 95 percent of Hungarian poultry breeding is done by small holders who are assisted by the authorities in various ways.

The incubating centers furnish the farmers with large numbers of day-old chicks of reliable breeds and strains.

Through the so-called cockerel scheme, the farmer is provided with reliable cocks for his flock.

Much attention is paid to selection, not only to obtain good production, but also to assure good constitution and good performance for an extended period.

THE PART PLAYED BY WOMEN IN THE POULTRY INDUSTRY IN GREAT BRITAIN

By EUNICE E. KIDD, *The Millers' Mutual Association, London, England*

In commenting on the emancipation of women, it is frequently remarked that modern woman has invaded almost every industry, every profession, and every service. Such a statement, however, is not true of the poultry industry in Great Britain, for in this case, woman has been there from the very beginning.

In the earliest references to poultry in British literature, woman is pictured as being in possession of the flock. In the first place, she kept them round the hearth in her house, to which homely scene Langland referred in 1399, when he wrote of[1] "the house-hen cherishing her chickens."

By the year 1500, the professional henwife had appeared—apparently a woman of power and responsibility, for according to "Colkeltie Sow," it is stated:[2] "He then charged his hen-wife to do her cure and make them fertile, and then to set them" (the eggs). Obviously, even then, the henwife made some attempts at controlled breeding!

Three hundred years later, we hear from Crabbe, in his "Parish Register"—in which he records the death of the "Managing Widow Goe"—of woman regarding her poultry from a much more commercial angle, for he states:

> "She lost her husband when their loves were young,
> "But kept her farm, her credit and her tongue,
> "(Poultry in groups still followed where ere she went)"

Soon after this, in 1816, Scott wrote of "a half-witted lad, who had a kind of charge of the Poultry under the old hen-wife," thus definitely establishing woman in a position of responsibility and authority in the profession. In Great Britain, therefore, where men and women work side-by-side in almost every branch of the industry, we do not speak of poultry farming as a postwar vocation which has provided a sphere of usefulness for the woman with initative and other suitable qualifications. Rather, we say, that, to the land-loving woman, the care of poultry is as much her natural heritage as the husbandry of the larger farm animals is the natural heritage of the man, who also feels that his roots spring from the soil.

[1] "be hous-henne cherichen hir chekonys."

[2] "He chairgeit sone hin hen-wyfe to do hir cure And mak thame fruct, than to set then (eggs)."

THE FARMER'S WIFE'S POULTRY

Up to 1910, except for the pioneers of specialist utility breeding, such as Mr. Tom Barron, Mr. Edward Cam, and Miss Edwards, poultry keeping was still mainly in the hands of the small holder and the farmer's wife, each of whom regarded their poultry-keeping ventures chiefly as a useful contribution to the domestic economy of the home. From the profits of her poultry, the farmer's wife often provided clothes for her children and herself, and as she took advantage of the valuable work which the specialist breeders were doing in the production of more highly fecund stock, she met with even greater success, so that in some cases (proud moment!) she was even able to offer assistance with the rent!

In 1914, at the outbreak of the Great War, increased production of eggs became a matter of urgency; farmers' wives enlarged their flocks, and every woman who could house a few hens in her orchard, her back garden, or on her husband's allotment, quickly arranged to do so, and women living in the country, with land at their disposal, and an urge to contribute to the Nation's food supply, started small farms of their own.

AN INDUSTRY WITH A SPECIAL PLACE FOR WOMEN

To the woman poultry farmer who could devote the whole of her time to the job, pedigree breeding made the strongest appeal; woman's natural gift of stock sense, her "way" with young creatures, her patience and her aptitude for detail, made her more fitted for this work than for pure commercial egg farming or the large-scale production of table chicken.

The names of Miss Nellie Bell, Miss Harrison Bell, Miss Kitchin, Miss Larkworthy, Miss Maddison, and the Misses Ransford have been widely known as poultry breeders ever since the early days of the war, and there are now hundreds of other women breeders in Great Britain who are following their example.

WOMEN IN THE POULTRY INDUSTRY IN SCOTLAND

In Scotland, the generalized nature of poultry and dairy farming and the large number of crofter and small-holder farms lend to the industry an aspect which brings it very prominently into the sphere of women's work. In consequence, the poultry educational work in Scotland is carried out almost entirely by women. There is a woman technical officer at the Department of Agriculture at Edinburgh, who is chief inspector for all the poultry work in the country, and who acts as a liaison between the Department and all the services.

There are also in Scotland three agricultural colleges with poultry departments where, in each case, a woman is in charge, and the advisory work in the counties is carried out by 32 women and 3 men and are under the supervision of these college authorities.

In Scotland, as in England, the purely commercial enterprises in the production of table eggs and chicken are more often undertaken by men than women, and men also specialize more in pedigree breeding than do the women, although the names of Miss Johnston of Comrie and Mrs. Grant Peterkin of Forres remind us of Scottish women's achievements in this connection.

The position of women in the poultry industry in Wales compares very closely with that of Scotland. Here, again, most of the poultry are kept on farms or small holdings in charge of the wife or daughter, although, as in Scotland, there is now a tendency for the men to specialize in breeding and commercial egg production.

COMMERCIALISM IN ENGLAND CREATED NEW DEMAND FOR TRAINED WOMEN WORKERS

In England, after the war—owing to the low capital sum with which one could start poultry farming and the opportunities it offered for an open-air life—a great number of men who had previously been in other businesses and professions entered the industry. In the majority of cases, they developed their farms on more commercial and specialized lines than had usually been seen before, and in so doing, created a host of specialist jobs suitable for women.

This influx of newcomers to the poultry industry naturally gave an impetus to the demand for poultry education, and women students became prominent among those presenting themselves for the examinations of the National Poultry Diploma Examination Board. Up to the present time, of a total of 207 diplomas granted in Great Britain, 106 are held by women and 101 by men.

After obtaining the diploma and gaining experience in such posts as chicken rearers, pedigree and trap-nest recorders, feeding and management of laying stock, candlers, and graders and packers of eggs and chicks, women students usually become manageresses of small breeding farms or of sections of large commercial farms, or frequently start farms of their own. A certain number, however, after further commercial experience, take posts as advisers or teachers under a local or college authority.

In England and Wales, 40 percent of the posts of the chief and assistant county advisers are open to women, and women hold 46 percent of the posts of manageresses of the egg-laying trials which are administered jointly by the county agricultural education authorities and the Ministry of Agriculture.

NOTABLE ACHIEVEMENTS OF WOMEN BREEDERS

Among women, as among men, there are naturally some who have achieved an outstanding degree of individual success in their work. Of any of the women breeders whose names are mentioned earlier in this paper, it may be said that they have won premier awards in both open laying trials and in international exhibitions, and their names are known as breeders of first-class poultry in every country to which British stock poultry have been exported.

Miss Larkworthy and Miss Maddison (and Miss Nellie Bell in her time) are outstanding examples of women who have contributed much more than good poultry to the industry. They have both seen long service as active members of the National Poultry Council, and a host of other important committees in addition, and Miss Maddison was president in 1935 of the largest poultry society in Great Britain and has also earned for herself a national reputation as a lecturer.

WOMEN IN UNUSUAL SPHERES

Another outstanding achievement in organization is the work of the Hon. Mrs. Adams, who has attained a remarkable degree of cooperation among the poultry farmers of Devonshire by establishing there an egg-packing station, a food distributing center, and a hatchery, all working on cooperative lines.

Among the more unusual work undertaken by women must also be recorded the very successful one-time editorship of "The Feathered World" by Mrs. E. Comyns Lewer, the important research work in poultry nutrition carried out at the Cambridge School of Agriculture by Dr. Ethel Cruickshank, and the work of advisory officer in poultry keeping to an organization representing the British Milling Industry by another woman. In the last case, in addition to the responsibility for a staff of lecturers (all men), the services of this woman are frequently lent to the poultry industry for special purposes. She has, for example, on two occasions been responsible for the designing of the British National Exhibit at the World's Poultry Congress, and last year she organized a dinner, which proved to be the largest gathering of the poultry keepers of Great Britain that had ever been held.

In general, women in the poultry industry in Great Britain seem to play much the same part as they do in the life of the Nation. Women built up the nursery of the industry from the house-hen and her brood in the fourteenth century to the farmers' wives' flock which are to be found on almost every general farm today. In these agricultural districts women still do all the teaching and the training. Men, on the other hand, are responsible for most of the big commercial developments, just as they are in national life, whereas women do the stay-at-home jobs—

chicken rearing and the light routine—just as they do in the life of the Nation. Here and there, in the poultry world, woman, by her own efforts, has made a contribution so useful to the whole industry that her name becomes well known, but there is one point on which men and women are, as yet, all square: No professional poultry farmer, either man or woman has, in the cause of the industry, succeeded in obtaining a Seat in Parliament!

SUMMARY

Contrary to general opinion, which is that women first came into the poultry industry at the outbreak of the Great War, British literature records that women have assisted in building up the poultry industry from the time of the househen and her brood, which was referred to in the fourteenth century.

Up to 1910, poultry-keeping was mainly the affair of the small holder and the farmer's wife, who regarded their flocks chiefly as a useful contribution to the domestic economy of the home. In 1914, however, at the outbreak of the War, although these farm flocks were considerably enlarged, many women having land at their disposal started small farms of their own in order to contribute to the Nation's food supply.

Some of the women wartime recruits to the industry are today numbered among the world's best-known pedigree breeders, and their work has been a constant source of inspiration to the industry.

In Scotland, the generalized nature of poultry and dairy farming lends to the industry the aspect which brings it very definitely into the sphere of women's work, and in consequence the poultry education work in that country is carried out almost entirely by women; 91 percent of the county instructors, the heads of all the college poultry departments, and the Government's technical adviser, are all women.

In England, in spite of the more commercialized aspect of the industry, women hold 51 percent of the national diplomas in poultry husbandry, 40 percent of the poultry educational posts, and 46 percent of the posts of manageresses of county laying trials.

Women have also figured prominently in the work of organization and have in many cases become well-known lecturers and presidents and chairmen of national organizations, or all of these.

THE POULTRY INDUSTRY IN DENMARK

By W. A. Kock, *State Counsellor for Poultry Culture, Copenhagen, Denmark*

Keeping of fowls for egg production, which is the most important branch of poultry farming in Denmark, has developed to a considerable extent and provides a supplementary source of income for many persons in the rural districts as well as in the small towns and villages. Hens are kept in all parts of the country, but most of them are found on the many thousands of farms on which the raising of poultry is the sole enterprise. This statement applies particularly to the many small holdings. These have more fowls to the acre than do the ordinary middle-sized and large farms.

In Denmark, as in other countries, there are independent poultry farms, but these have not contributed so much to the development of the industry as the aggregate production of eggs from the many thousands of small producers scattered over the whole country. It is this latter group which testifies to the economic importance of poultry keeping in Denmark.

Incubators and artificial brooders are used to a great extent, and many poultry keepers have no breeding stock at all but buy day-old chicks from the hatchery. Keeping of waterfowls and turkeys is practiced to some extent.

Great efforts have been made to improve the breeds from an economic point of view. White and Brown Leghorns have gained the most general and extensive popularity with our practical poultry keepers. Among the American breeds, Plymouth Rocks and Wyandottes, especially the white varieties, and later the Rhode Island Reds have come into great favor. Next to Leghorns, the Rhode Island Reds are the most common. The Light Sussex, which are also very suitable for our climate and conditions, are kept extensively and have become very popular. Of the utility breeds mentioned, there is an excellent and prolific supply, thanks to the long and consistent work in the field of breeding and the great stress which has been laid on vitality and health. In addition to the pure breeds named, first crosses have become popular with many of our poultry keepers, replacing the common barnyard fowls.

As far as the production and marketing of eggs are concerned, Danish eggs have gained a high position among our leading agricultural products. This fact is due largely to the improved methods of management used by the producers as well as to the regular collection of eggs and their careful grading, candling, and packing at the many up-to-date egg-packing establishments throughout the country. Traveling collectors call on the different egg producers at regular intervals, or the producers bring their eggs to a local egg circle, merchant, or cooperative supply store. Here the eggs are placed in special boxes provided with cardboard sections and forwarded to one of the egg-packing establishments.

The export of eggs is undertaken partly by private firms and partly through cooperative associations, and the import, export, and sale of eggs is under Government control. Exporters must be authorized by the Minister of Agriculture, and second-grade eggs must not be exported. Every fresh Danish egg must be marked with the word "Danish" in an oval, and every egg imported into Denmark must bear the name of the country of origin, which also must appear on the boxes. All eggs intended for export must be uniformly graded. There are regulations regarding treatment and packing, and Government inspectors check the quality, grading, and weight of the export eggs at the egg-packing establishments, harbors, and railway stations. If the eggs do not comply with the regulations, they are confiscated and the exporter is fined.

The progress of poultry production necessitated the establishment of several special poultry slaughteries, both private and cooperative. The slaughteries handle all kinds of poultry, and some have special departments for fattening of fowls, especially chickens. The Ministry of Agriculture has laid down certain regulations with reference to poultry slaughteries and to the killing, treatment, uniform sorting, marking, and packing of poultry.

Statistics show that for many years eggs have ranked third on our list of agricultural exports, being exceeded only by butter and bacon. Last year the export of Danish eggs amounted to 79 million scores with a total value of 139.1 million kroner.[1] The value of poultry exported during the same year amounted to 5.2 million kroner.

According to the census of July 1938, there were in the rural districts in Denmark 27,649,000 hens, cocks, and chickens; and in 1933, the last year in which waterfowls and turkeys were counted, there were 1,049,800 ducks, 449,700 geese, and 116,000 turkeys. There are about 375,000 poultry keepers in Denmark.

Systematic endeavor to improve poultry keeping and egg production is undertaken by the Government Committee on Poultry Breeding; the Government Committee on Eggs; the Society of Danish Poultry Breeders, which is divided into 25 county circles; and the Joint Committee for Poultry Breeding as well as by a considerable number of poultry clubs, agricultural societies, and societies of small holders.

Among the most important measures pursued by these committees and societies are the holding of lectures and courses in practical poultry keeping, the establishment of control stations, the distribution of eggs for hatching from the recognized breeding centers, the holding of egg-laying tests, annual competitions between whole flocks of fowls, poultry shows, and the carrying out of advisory work by a special staff of advisers.

The National Committee for Young People's Agricultural Work has arranged competitions and courses in poultry keeping for boys and girls of the rural districts. At the Royal Veterinary and Agricultural College, as well as at many of the agricultural schools, instruction is given in poultry culture, and at the Laboratory for Agricultural Research, various tests and experiments relating to poultry are undertaken. The laboratory has established its own experimental poultry farm on property belonging to the Ministry of Agriculture and has also undertaken the management of the fowls which are entered in the official egg-laying test at another Government experimental farm, where a special egg-laying control station is founded and run by the poultry organizations.

The combating of poultry diseases has received much attention from the Government, the office of the chief veterinary officer, the Veterinary Serum Laboratory, and the Royal Veterinary and Agricultural College, where the examination, dissection, and treatment of the fowls at the poultry clinic are carried on free of charge.

Among the previously mentioned measures that have been carried out in our country for the furtherance of poultry breeding, and in particular fowl rearing, the annual competitions among entire, well-conducted flocks of fowls are recognized as one of the most important factors in the encouragement of poultry breeding along truly practical and economic lines, and have greatly contributed to the development of pedigree breeding in Denmark. The chief object of the competitions is to show other poultry keepers how profitable well-kept poultry can be made to be, to demonstrate the necessity of sensible breeding, and to form prominent distributing centers for eggs for hatching, for day-old chicks, and for breeding birds.

There is one leading competition for the whole country and a local competition in every county. Every year poultry keepers are invited to enter the competitions which extend from October 1 to September 30. The prizes awarded depend on the impressions gained by the joint committee from unannounced inspections of the breeds and farms of competitors and on the breeding results that they obtain with their flocks. Points are awarded, and among other things competitors are required to weigh and measure the eggs from individual hens at certain intervals and to record the color of shell.

These flock competitions form the basis of the yearly selection of breeding centers. Competing flocks which consist of but one breed, and which are awarded a first prize, are acknowledged as breeding centers for the ensuing year. No poultry keeper can obtain prizes for his stock unless he can produce a certificate issued by the serum laboratory to the effect that his birds are free from white diarrhea. Without such a certificate, he cannot get acknowledgment as a breeding center or be awarded prizes in the competitions.

Another most useful factor in breeding is the progeny tests which take place at the egg-laying

[1] One American dollar equals 4 kroner, 80 öre; one krone equals 100 öre.

control station where flocks of fowls are accepted with the object of ascertaining the value of selected cocks through an examination of the egg yield of their daughters. The egg yield of the dams is also taken into consideration.

The selection of cocks is made by the Government Committee on Poultry Breeding, the requirements being that the cock must be purebred, of good health, development, and vitality, and of good physical appearance. Any daughters which are to qualify must likewise be of good physical appearance. The pedigree of the cock or a progeny test must be approved by the Government Committee, and the exact egg yield of the hens to which he was mated must be known. If a cock is selected by the committee, his owner must send to the control station eight well-developed daughters, and he must have in his flock at least 12 additional daughters from the same cock. The control period extends from October 15 to September 30, all flocks being kept under the same conditions and all being fed alike. It is preferred that the pullets in each flock be daughters of eight dams which have had excellent egg yields during the first year of laying.

Before the cock can be registered in the Official Pedigree Book for Male Birds published by the Government Committee on Poultry Breeding, his daughters at the control station must have made a good record for the entire year as well as in the autumn and winter months and must have produced eggs of good color and shape and of at least 58 grams in weight. The cock must have shown the ability to increase egg yield as indicated by the daughters making higher records than their dam or, at any rate, very favorable records. The yield of other daughters of the cock is also taken into consideration and must be in a reasonable proportion to that of the daughters at the control station. In addition, all daughters must show desirable exterior qualities.

SUMMARY

Throughout Denmark fowls are kept for egg production, and practically every farmer, particularly the many small farmers, keep fowls. Leghorns, the American breeds (Plymouth Rocks, Wyandottes, and Rhode Island Reds), and Sussex are the most common breeds kept, and great efforts have been made to improve the breeds. The eggs are subjected to Government control and during a number of years have held third place among exports. The export of poultry has also developed, and special export slaughteries have been established. Systematic work to promote poultry breeding is undertaken in different ways by associations and organizations. Special importance is attached to the annual competitions among entire, well-conducted flocks of fowls, which form the basis of the yearly selection of breeding centers. The progeny tests take place at an official egg-laying control station, and the selection as well as the registration of cocks in the Official Pedigree Book for Male Birds is undertaken by the Government Committee on Poultry Breeding.

DIE GEFLÜGELZUCHT IN EESTI (ESTLAND)

Von ELMAR LIIK, *Professor der Tierzuchtlehre an der Universität zu Tartu*

Vor der Gründung der Republik Eesti gab es hier eine Reihe verschiedener Hühnerrassen, die im Laufe der Zeit von Fachliebhabern importiert wurden. Mit dem Erreichen der Selbständigkeit nach dem Weltkriege, wurde in Eesti folgende Hühnerrassen als geeignet für eine Hühnerzucht amtlich anerkannt: weisse Leghorn und rebhuhnfarbiges Italienisches Huhn als leichtere Legehühner und Plymouth-Rock sowie Rhode-Island als schwerere Fleisch- und Legehühner.

Von diesen Rassen haben bei den Geflügelzüchtern die weissen Leghorns am meisten Anklang gefunden, auf die als nächste Rasse die rebhuhnfarbigen Italiener folgen. Letztere aber nehmen ab, denn die Beschaffung von rebhuhnfarbigen Italienern zwecks Blutauffrischung ist in Eesti erschwert.

Von den schwereren Rassen werden immer mehr die Rhode-Islands bevorzugt, während die früher mehr verbreiteten gesperberten Plymouth-Rocks in den Hintergrund treten. Von den Fleischhühnern findet man in geringer Zahl lachsfarbige Faverolle.

Ausser den genannten Hühnerrassen sind vom übrigen Geflügel anerkannt: Toulouser und Emdener Gänse, Pekinger und Rouaner Enten, amerikanische bronzefarbige und weisse virginische Truthühner.

Die Geflügelzüchtung und deren Förderung liegt in den Händen des "Eesti Linnukasvatajate Selts" (E. L. S. = Geflügelzüchter-Verein in Eesti), mit dem Sitz in der Hauptstandt Tallinn bei der Landwirtschaftskammer. Die Fortschritte in der Geflügelzucht überwacht die E. L. S. hauptsächlich vermittelst der Zuchtzentren (Zuchtstationen). Zur Auswahl der Zuchtzentren werden von der E. L. S. jährlich über das ganze Reich "Geflügelzucht-Wettbewerbe" veranstaltet, die über ein ganzes Jahr sich hinziehen, beginnend mit dem 1. November.

An den oben genannten Wettbewerben können sich die Zuchten mit ihrer gesammten Geflügelzucht beteiligen oder auch nur mit einem Zweige derselben, wie der Hühner- Gänse- Enten- oder Truthühnerzucht. Von dem Teilnehmer om Wettbewerbe müssen wenigstens 25 Hühner und 2

Hähne von einer anerkannten Rasse vorgestellt werden, während von den Gänse- Enten- und Truthühnerzuchten nur 4 weibliche und 2 männliche Vögel annerkannter Rasse verlangt werden. Die Geflügelzuchten müssen über ordnungsmässige Räumlichkeiten für das Geflügel verfügen, dazu eine Buchführung, aus der hervor—gehen muss: der Eier-Ertrag des Geflügels und die jährlichen Einnahmen und Ausgaben u. s. w.

Die aus Sachverständigen bestehende Kommission kontrolliert und bewertet alle Wettbewerbteilnehmer in der Geflügelzucht nach Punkten, wie es aus der Tabelle 1 zu ersehen ist:

TABELLE 1

Bei der Beurteilung werden berücksichtigt	Maximalzahl der Punkte	Minimale erforderliche Punktzahl für die Preise I	II	III
1. Räume und Einrichtung	20	18	15	13
2. Fütterung und Pflege	25	22	20	14
3. Ertrag und Kontrolle	25	20	15	13
4. Rassenmerkmale, Typus und Gesundheit	15	13	10	8
5. Rentabilität und Gesamteindruck	15	12	10	7
in Summa	100	85	70	55

Den sich bewerbenden Zuchtbetrieben werden Ehrenpreise zugesprochen wie Geldpreise, Diplome und Wertgegenstände. Die mit dem I. Preise gekrönten Geflügelzuchten bleiben so lange Zuchtstation, bis die Ergebnisse des nächsten Wettbewerbes bekannt gegeben werden. Der Wert der Zuchtstation und die ihr bei der Bewertung zuerteilten Punkte zerfallen in 3 Klassen: I, II und III.

Von einer Zuchstation Nr. III wird verlangt: (1) dass die Geflügelzucht mehr oder weniger den Anforderungen einer Zuchtstation entspricht und beim Wettbewerb wenigstens 85 Punkte erhalten hat. (2) dass in der Geflügelzucht am Schluss des Wettbewerbsjahres wenigstens 2 Hähne und 15 Hühner aus der ersten Generation im Zuchtbuch sind.

Von einer Zuchtstation Nr. II wird verlangt: (1) dass die Geflügelzucht ihre Erträge und Rentabilität vergrössert hat und bei der Bewertung im Wettbewerb wenigstens 90 Punkte erhalten hat, (2) dass in der Geflügelzucht am Ende des Bewerbsjahres wenigstens 2 Hähne und 15 Hühner aus der dritten Generation im Zuchtbuch sind, (3) dass die Geflügelzucht wenistens 1 Jahr der Zuchtstation Nr. III angehört hat.

Von einer Zuchtstation Nr. I wird verlangt: (1) dass die Geflügelzucht vorbildlich ist in Bezug auf Ertrag, Rentabilität, Rasse, Typ und Gesundheit und bei der Bewertung im Wettbewerb wenigstens 95 Punkte erhalten hat, (2) dass in der Geflügelzucht am Ende des Wettbewerbsjahres wenigstens 2 Hähne und 15 Hühner aus der 5. Generation im Zuchtbuch sind und alle reinrassig, (3) dass die Geflügelzucht wenigstens 1 Jahr der Zuchtstation Nr. I angehört hat.

Ausser den oben genannten Bedingungen müssen die Zuchtstationen auf Verlangen des E. L. S. 6 Jungühner auf die Kontrollstation schikken die 11 Monate dort bleiben. Die Kontrollstation ist ein staatliches Unternehmen, wo Eiererträge und Futterverbrauch kontrolliert werden.

In jeder Zuchtstation müssen wenigstens 2 Zuchtstämme sein, wobei auf 1 Hahn bei den leichteren Rassen 10–15 Hühner kommen sollen, während bei den schwereren nur 6–10 Hühner auf 1 Hahn entfallen. Es ist wünschenswert, dass das zur Zucht bestimmte Geflügel wenigstens 2 Jahre alt ist und dass 1 Huhn folgenden erstjährigen Legeertrag aufweisen kann: (1) bei den leichten Rassen (Leghorn, Italiener) 140 Eier mit wenigstens 55 g Durchschnittsgewicht pro Ei. (2) Bei den halbschweren Rassen (Rhode-Island und Plymouth-Rock) 130 Eier mit wenigstens 56 g Durchschnittsgewicht pro Ei, und (3) bei den Fleischhühnern (Faverolle) 110 Eier mit wenigstens 55 g pro Ei.

Die Zuchtstationen unterstehen der tierärztlichen Kontrolle der E. L. S.

Bei den Geflügelfarmen, die beim Wettbewerb des Jahres 1937 teilgenommen haben, war laut Angaben des E. L. S. der mittlere Legeertrag eines Huhnes 162 Eier jährlich.

In den Zuchtstationen I. Klasse war der Legeertrag der im 1. Jahre legenden Hühner durchschnittlich 228,8 Eier, und der durchschnittliche Legeertrag aller Hühner 186,8 Eier.

In den Zuchtstationen II. Klasse waren die entsprechenden Zahlen 187,9 und 164,3 Eier und bei denen der III. Klasse: 170,9 und 156,4 Eier.

Von den Rechten der Zuchtstationen wären zu nennen, dass sie von den Beratern des E. L. S. umsonst konsultiert werden, dass sie verschiedene Vergünstigungen und Hilfsgelder bekommen zum Kauf und Verkauf von Rassegeflügel.

In den mehr zurückgebliebenen Gegenden sind zur Verbesserung und Blutauffrischung des Geflügelrassematerials sog. Rassegeflügelpunkte gegründet worden. Diesem wird gewöhnlich einige reinrassige Hühner und ein reinrassiger Hahn kostenlos gegeben mit der Bedingung, dass das Geflügel zwei Jahre sorgfältig gehalten wird und im Frühjahr Bruteier zu dem Preise von Speiseeiern verkauft werden.

Seit dem Jahr 1928 wird vom E. L. S. ein Zuchtbuch geführt für die anerkannt reinrassigen Hühner und Hähne. In das Zuchtbuch werden Hühner zum Schluss der ersten Legejahres eingetragen, Hähne aber, wenn sie wenigstens $1\frac{1}{2}$ Jahre alt sind, wenn das Geflügel vollkommen gesund ist und den Anforderungen im Exterieur und im Körperbau entsprechen. Die in das Zuchtbuch eingetragenen leichten und schweren Rassen müssen im ersten Legejahr 160 und 150 Eier gelegt haben mit einem Durchschnittsgewicht von 55 und 56 g pro Ei. Die im Zuchtbuch eingetragenen Hühner werden ihrem Legeertrag entsprechend in 3 Klassen eingeteilt, wie es aus der Tabelle 2 zu ersehen ist.

Die Anforderungen an die im Zuchtbuch aufzunehmenden Hähne sind grössere. So muss die Mutter eines Hahnes bei den leichten Rassen wenigstens 190 Eier im 1. Jahre legen mit einem Durchschnittsgewicht von wenigstens 57 g, das Gewicht des Hahnes muss wenigstens 2 kg. betragen. Bei den schwereren Rassen muss die Mutter des Hahnes im 1. Jahr wenigstens 180 Eier gelegt haben mit einem Durchschnittsgewicht von wenigstens 58 g, wobei das Gesammtgewicht des Legeertrages vom 1. Jahr wenigstens 10 kg betragen muss.

Die Mutter, Grossmutter und die Mutter des Vaters des in das Zuchtbuch aufzunehmenden Hahnes müssen auch im Zuchtbuch stehen. Die Kategorie des Zuchtbuches dieses Hahnes wird bestimmt durch die Nachkommen desselben und zwar durch die Hennen. Der Hahn wird in die Kategorie gerechnet, welche die meisten Nachkommen aufweist, die zur Nachkommenschaft des 1. Jahres gehören, in denen dieser Hahn als Zuchthahn gebraucht wurde.

Tabelle 2

Hühnerrassen	Klasse	Minimaler Ertrag des I. Jahres	Minimales mittl. Gew. des Eies.	Gesammtgew. des Jahresertrages kg	Anmerkungen
Leichte R. (Leghorn, Italiener)	I	200	57	......	Aus dem Gew. 3-er Eier zu Beginn des Monats wird das Durchschnittsgew. des Eies im Monat bestimmt.
	II	170	56	......	
	III	160	55	......	
Schwere R. (Rhode Islands, Plymouth-Rocks)	I	190	58	11	
	II	170	57	10	
	III	150	56	8,5	

Das ins Zuchtbuch vermerkte Geflügel wird mit einem fest vernieteten Fussring versehen, auf dem die Nr. des Zuchtbuches vermerkt ist.

Zur Förderung der Geflügelzucht tragen auch noch alljährliche landwirtschaftliche Ausstellungen mit Geflügelzuchtabteilungen bei, wobei das auf den Ausstellungen gezeigte Rassegeflügel und Geflügelfarmen prämiert werden.

DIE GEFLÜGELZUCHT IN DEN GEWÖHNLICHEN BAUERNWIRTSCHAFTEN

Vor dem Weltkriege war die Geflügelzucht in den Bauernwirtschaften im Allgemeinen auf einer niedrigen Stufe. Seit der Zeit der staatlichen Selbstädigkeit ist die Geflügelzucht in den Bauernwirtschaften kräftig fortgeschritten.

In den letzten Jahren wird besonderer Wert auf sorgfältig gebaute Hühnerställe gelegt. Durch den E. L. S. wird mit Hilfe von Geldunterstützungen der Bau von hygienisch einwandfreien Hühnerställen angeregt. Zu diesem Zweck sind sogar dementsprechende Pläne für Standardhühnerställe ausgearbeitet. Eine entsprechende Kommission bewertet im Herbst auf Wunsch der Geflügelzüchter die im Sommer gebauten Hühnerställe und erteilt nach den Bewertungsergebnissen eine entsprechende Geldprämie. Mit Hilfe dieser Prämien werden in den Bauernwirtschaften am meisten Hühnerställe für 50–100 Hühner gebaut. So waren z. B. im Jahr 1937 von den prämierten Hühnerställen für 50 Hühner eingerichtet—26 Prozent, für 50–100 Hühner—47 Prozent, für 100–150 Hühner—15 Prozent und für über 150 Hühner—12 Prozent. Dabei ist ein m^2 Bodenfläche für 2 Hühner berechnet. Im Allgemeinen lassen die Hühnerställe noch viel zu wünschen übrig, denn an vielen Orten fehlen spezielle Ställe für Hühner. Diese werden im Winter meistens mit anderen Haustieren zusammen, hauptsächlich in Rindviehställen gehalten, während sie im Sommer frei umherlaufen.

Auch auf dem Gebiet der Fütterung ist in den letzten Jahren ein Fortschritt zu merken. Die früher einseitige Nahrung wird immer vielseitiger. Besondere Kraftfuttermischungen sind zum Verkauf freigegeben, die immer mehr und mehr gekauft werden. Zur Regulierung des Eiweissgehaltes bekommen die Hühner Magermilch.

Das Ausbrüten und Aufziehen von Küken vollzieht sich grösstenteils auf natürliche Weise. In den letzten Jahren hat sich der Gebrauch von Inkubatoren vergrössert. In den Bauernwirtschaften sind gewöhnlich Gerste- und Hafergrützen die Hauptnahrung der Küken. Da aber die Küken frei umherlaufen und selbst natürliche Nahrung suchen, so macht ein derartiges Füttern mit Grütze keine Schwierigkeiten bei der Aufzucht von Junghühnern.

In den letzten Jahren stieg der Kauf von Eintagsküken aus den Zuchtstationen, wozu besonders geldliche Unterstützungen beigetragen haben.

ZUSAMMENFASSUNG

Zusammenfassend kann man sagen, dass die Geflügelzucht—besonders auf dem Gebiet der Hühnerzucht, welche in Eesti einen der rentabelsten Wirtschaftszweige darstellt, in den letzten Jahren mehr fortgeschritten ist, wozu die in dieser Schrift angeführten Bestimmungen viel beigetragen haben. Zum Fortschritt auf dem Gebiet der Geflügelzucht hat auch die E. L. S. mit ihren Arbeitskräften viel beigetragen, wie auch die Staatsregierung und die Eierexportfirma "Eesti Munaeksport" in Form von geldlichen Unterstützungen.

Geflügelzucht wird in Eesti in den landwirtschaftlichen, Tierzucht- und hauswirtschaftlichen Schulen gelehrt, sowie besonders in den zu diesem Zweck veranstalteten Schnellkursen. Eine höhere Bildung auf dem Gebiete der Geflügelzucht bekommt man auf der Universität zu Tartu in der Landwirtschaftlichen Fakultät, wo 2 Professoren der Tierzuchtlehre tätig sind, von denen

einer die Aufgabe hat, die Studierenden der landwirtschaflichen und tierärzlichen Fakultäten auch auf dem Gebiet der Kleintier- und Geflügelzucht (Schweine-, Schaf- und Geflügelzucht) zu lehren. Bei diesem Lehrstuhl befindet sich seit dem Jahre 1937 auf dem Universitätsgute Raadi auch eine Versuchsstation für Kleintierzucht (Väikeloomakasvatuse Katsejaam), wo es den Studierenden möglich ist, auf dem Gebiet der Geflügel- und Kleintierzucht praktisieren und bei der entsprechenden Lehrkraft in der Geflügelzucht entstandene Probleme mit Hilfe von entsprechenden Versuchen und Beobachtungen zu lösen.

Zum Schluss bringe ich noch einige Zahlen, um die Geflügelzucht in Eesti zu charakterisieren. Im Jahre 1928 gab es in Eesti 865.590 Stück Hausgeflügel, im Jahr 1938 aber 1.991.030 Stück, womit sich also die Zahl an Hausgeflügel in dem erwähnten Zeitabschnitt um 130 Prozent vergrössert hat. Es ist möglich, diese Zahl noch stark zu vergrössern, denn durchschnittlich werden in den Bauernwirtschaften nur 10 Hühner gehalten.

Anderes Hausgeflügel trifft man in Eesti verhältnismässig wenig. So werden innerhalb der Gesammtzahl an Hausgeflügel ca. 6 Prozent Gänse gehalten und 2-3 Prozent anderes Geflügel, wie Enten und Truthühner.

Wenn man den Legeertrag der Hühner vom Jahr 1937 mit dem mittleren Gesammtlegeertrag von 10 Jahren vergleicht, so sieht man eine Steigerung vin 58 Prozent. Die Steigerung des gesamten Legeertrages ist ganz besonders in der Vergrösserung der Hühnerzahl zu suchen. Aber auch der mittlere Legeertrag eines Huhnes ist gestiegen: im Jahre 1927—96,1 Eier und im Jahr 1937 108,4 Eier. In den Zuchststationen und besseren Geflügelzuchten ist der Legeertrag eines Huhnes viel grösser als der des staatlichen Durchschnitts, so wie es auch schon oben erwähnt ist.

SUMMARY

Of the several breeds of chickens raised in Estonia at present, White Leghorns and Rhode Island Reds are preferred. Domestic poultry other than chickens are relatively unimportant. Of the total poultry produced, about 6 percent are geese and 2 to 3 percent are ducks and turkeys.

Poultry breeding is in the hands of the Association of Poultry Breeding in Estonia. This work is carried on mainly through breeding stations, which are selected by means of Nation-wide poultry-breeding contests, which are held annually. Breeding farms which gain first prize at these contests become recognized breeding stations until another contest is held.

In the less advanced districts, so-called purebred-poultry stations have been established. These stations receive, free of charge, a few purebred hens and a purebred rooster with the understanding that the hatching eggs will be sold at the price of market eggs.

The Association of Poultry Breeding in Estonia, since 1928, has kept a poultry-pedigree register for all recognized purebred hens and roosters.

Annual agricultural expositions, with poultry departments, also contribute to the promotion of the poultry industry by awarding prizes to poultry farms and to the breeding stock exhibited at these expositions.

Poultry keeping on general farms has made considerable progress since the World War. Emphasis is being placed on well-constructed hen houses, better feeding, and on the incubation and rearing of chicks.

In 1928 there were about 865,000 domestic poultry in Estonia; in 1938 the number was nearly 2,000,000. In 1927, the average production per hen throughout the entire country was 96 eggs; in 1937 this number had increased to 108.

A COORDINATED BREEDING AND PULLORUM-CONTROL PROGRAM FOR THE UNITED STATES: THE NATIONAL POULTRY IMPROVEMENT PLAN

By PAUL B. ZUMBRO, *Senior Poultry Coordinator, Bureau of Animal Industry, United States Department of Agriculture, Beltsville, Maryland, U. S. A.*

The hatchery industry expanded rapidly in this country beginning in 1918 with the advent of the forced-draft incubator and the admittance of day-old chicks to the United States mails in the same year. During the period of most rapid expansion, it was possible for many hatcheries to sell baby chicks with little regard to quality or advertising claims.

Progressive hatcherymen, poultrymen, and other poultry leaders soon recognized the need of establishing minimum standards for the production of hatching eggs, baby chicks, and poultry breeding stock and of having official terminology that could be used only by those breeders and hatcherymen meeting these high standards. In the year 1900, Rettger of this country discovered that pullorum disease was caused by the microorganism *Salmonella pullorum*. It was later determined that pullorum disease was transmitted by the hen through the egg to the baby chick and that the standard tube-agglutination test was a satisfactory means of detecting the breeding birds infected with pullorum disease. Pullorum testing by the tube-agglutination method was begun at an early date in the Northeastern States, and the term "accredited" was used to designate those flocks in which no reactors were found. In about 1921, accredited hatchery programs were developed in Wisconsin and California. The programs in these two States provided standards especially for the selection of breeding birds and hatching eggs, sanitation in the operation of hatcheries, and truthfulness in advertising. In rapid succession many of the States developed poultry-improvement programs of one kind or another. The requirements and terminology differed, but all had the same purposes—to improve the production and standard qualities of poultry and to reduce losses of baby chicks from disease.

Many benefits resulted from these State poultry-improvement programs. Because of the lack of coordination among programs and the use of conflicting terminology, however, the need for a coordinated national plan with uniform provisions and terminology became apparent and was first considered in 1925. Since some of the State programs had been in operation for a number of years, it was not an easy task to develop a plan that would be acceptable to the industry in all States. However, the poultry leaders from all sections of the country who worked diligently on this problem for about 10 years were finally successful in formulating what is now called the National Poultry Improvement Plan. In the development of this national plan, consideration was given to the experience of industry members and State officials in the operation of State programs.

ADMINISTRATION OF THE PLAN

The plan, which was placed in operation July 1, 1935, is administered cooperatively by an official State agency in each of the cooperating States, and the Bureau of Animal Industry of the United States Department of Agriculture. The official State agency recognized by the Federal Bureau of Animal Industry is usually the agency that was administering the State poultry-improvement program prior to the adoption of the national plan. It may be the State department of agriculture, State college of agriculture, livestock sanitary board, or a poultry-improvement board or association consisting of representatives of one or all of the above agencies and the cooperating breeders and hatcherymen. Authority for an official State agency to administer the plan within the State is a memorandum of agreement between the recognized group and the Federal Bureau of Animal Industry. This State agency directs, supervises, and is responsible for flock selection, testing for pullorum disease, and other local administrative work involved in the operation of the plan. The Bureau of Animal Industry is responsible for coordinating the program among the States in which the plan is in operation.

GENERAL FEATURES OF PLAN

The plan is Nation-wide in scope, the same minimum standards being applied regardless of the location of the industry member who is participating. The adoption of the plan on the part of States or individual industry members is entirely voluntary, but participants must meet its minimum requirements. Any poultry breeder, hatcheryman, or flock owner in a State having an official State agency for administering the plan, may participate by signing an agreement with this agency and complying with the provisions of the plan. Following proper certification of the quality of his flock and hatchery products, such flock owner, hatcheryman, or poultry breeder may then use the emblem, designs, and terminology of the National Poultry Improvement Plan in describing and advertising his flock or hatchery products. Thus, those who are cooperating in the plan and complying with its provisions receive official recognition for doing so, and through the use of terminology that has the same application in all parts of the country, farmers and poultrymen are enabled to buy poultry breeding stock and hatchery products with more assurance regarding quality.

Every effort is made to have the administration of the plan as democratic and cooperative as possible. Each year a 4- or 5-day national conference has been held for the purpose of considering fundamental poultry-breeding and pullorum-control principles and practices, administrative problems, and proposed changes in the provisions of the plan in line with experience and new findings of fact. These conferences are attended by representative poultry breeders and hatcherymen and poultry officials from the cooperating States. One official delegate has been selected by the participating industry members in each State. An excellent opportunity is provided in these conferences for the State officials and industry members to confer among themselves regarding the provisions of the plan and their administration, and to consult with and advise Federal officials regarding methods of putting the rules and regulations into effect so that the greatest value may be obtained by the poultry industry through the plan. A part of the program is devoted to discussions of the fundamental problems involved in breeding for production qualities, egg size, good hatchability, good livability, and good interior egg quality and the most practical methods of controlling pullorum disease. When proposed changes are to be considered at the conference, they are sent to official State agencies well in advance of the conference for the consideration of those administering and participating in the plan. In each State the official delegate is instructed on the stand he shall take regarding the various proposals. Only those proposed changes that receive a majority vote of the delegates at the conference are considered by the Bureau of Animal Industry in revising the plan. This procedure makes the provisions of the plan entirely democratic and subject to change from time to time as the program can be improved.

THE BREEDING STAGES

The plan gives recognition to breeding principles that have demonstrated their value in improving the breeding and production qualities of poultry by including five progressive breeding stages, namely, U. S. Approved, U. S. Verified, U. S. Certified, U. S. Record of Performance, and U. S. Register of Merit. The requirements for these five breeding stages vary enough to permit participation with the minimum of improvement work and yet give recognition for advanced breeding work. Provision is made for improvement in production qualities through the selection of breeding birds on the basis of physical appearance, physiological changes, production records, pedigree, and progeny test.

In the U. S. Approved breeding stage, the breeding birds are selected for constitutional vigor and for standard-bred and production qualities. In the U. S. Verified and U. S. Certified breeding stages, the birds must meet these same requirements and in addition the males are selected on the basis of pedigree. Males to head U. S. Verified flocks must be from flock matings of U.S.R.O.P. males and U.S.R.O.P. females. The dams' and sires' dams' records of these males must be at least 200 eggs, averaging at least 24 ounces per dozen. In the U. S. Certified breeding stage, the males are individually pedigreed and entirely free from standard disqualifications. The sire's dam's record for males to head U. S. Certified flocks must be at least 225 eggs averaging at least 24 ounces per dozen.

It will be noted that the three least advanced breeding stages of the plan are dependent on U. S. Record of Performance flock owners to supply foundation breeding stock. Thus the quality of the hatchery products in these lower breeding stages is improved in direct proportion to the quality of the breeding work done by the U.S.R.O.P. flock owners. This breeding stage provides for trap-nesting and pedigree-breeding at home under semiofficial supervision. Selection is almost entirely on the basis of production records. The females to be used as breeders must lay in a year 200 eggs or more, averaging at least 24 ounces per dozen. The males must have come from females which have laid 225 eggs or more in a year. In addition, both males and females must be free from standard disqualifications and all chicks are individually pedigreed and wing-banded at hatching time. Even though this stage of the plan has not yet been modified to include selection on the basis of progeny testing, more and more of the U.S.R.O.P. flock owners are selecting the birds to be used in their single male matings on the basis of performance of the sisters and daughters rather than on the basis of individual production records alone.

It is generally recognized by leading poultry breeders and geneticists that the best measure of the worth of a breeding bird is the kind of progeny it produces. Full recognition is given to selection on the basis of the progeny test in the U. S. Register of Merit breeding stage, the most advanced breeding stage of the plan. For males to qualify as U.S.R.O.M. males, a minimum of 20 and at least one-third of their daughters entered under U.S.R.O.P. supervision must qualify as U.S.-R.O.P. females. For females to qualify as U.S.R.O.M., a minimum of 4 and at least one-third of their daughters must qualify as U.S.-R.O.P. females. Males that are used in U.S.R.O.P. matings as cockerels must be at least 2½ years of age before they can qualify as U.S.R.O.M., and females must be at least 3½ years old before they can qualify unless they have been used in U.S.R.O.P. matings as pullets. There has been a steady increase in the number of birds qualifying in the U.S.R.O.M. breeding stage.

BASIS FOR U.S.R.O.M. QUALIFICATION

In determining the minimum number and percentage of U.S.R.O.P. daughters necessary to qualify a female as U.S.R.O.P., consideration has been given to the standard error of the difference when different numbers of pullet progeny are used as a base. In calculating the minimum requirements of the U.S.R.O.M. breeding stage, 12 pullet progeny are used as a base with a minimum of four, or 33⅓ percent, qualifying as U.S.R.O.P. Furthermore, this is a practical number in actual breeding operations, as is illustrated in table 1.[1]

TABLE 1.—*Number of eggs and chicks necessary to obtain 11, 12, and 24 pullets*

Item	Estimated number to produce—		Actual averages to produce 11 pullets[1]
	12 pullets	24 pullets	
Number of chicks hatched to obtain standard number of pullets	36	72	33
Number of eggs set to obtain number of chicks hatched	60	120	50
Number of days of production to obtain required number of eggs	100	200	84

[1] Based on more than 1,000 Single-Comb White Leghorn chicks.

The figures in this table are based on averages, and any dam that qualifies for U.S.R.O.M. must be better than the average in one or more characteristics. In addition to this, if any individual's progeny has poor viability or poor second-year production or poor hatchability it would be increasingly difficult for the dam to qualify as U.S.R.O.M. In other words, the present requirements necessary for qualification in the U.S.-R.O.M. stage are sound, well balanced in respect to economical characteristics, and above all, practical.

The question naturally arises as to whether a dam with fewer than 12 pullet progeny can qualify for U.S.R.O.M. She may have fewer than 12 pullet progeny, but in such cases a greater per-

[1] KNOX, C. W. Methods of sampling in relation to egg production. Report of the 1938 Conference on the National Poultry Improvement Plan. 1938.

centage of her pullets would have to qualify for U.S.R.O.P. An extreme case, for example, is a dam with only 4 pullet progeny all of which qualify for U.S.R.O.P. Therefore, 100 percent of her pullets qualified for U.S.R.O.P., none were disqualified, and none died. As 4 of her pullets out of 4 qualified, she could be no worse than the dam with 4 out of 12 pullets qualifying and is probably a better dam than the latter one.

REQUIREMENTS FOR HATCHING EGGS

Improvement in the quality of market eggs is another consideration in the national plan. All eggs used for hatching purposes are required to be carefully selected for size, shape, color, and freedom from tints. U. S. Approved and U. S. Verified hatching eggs weigh at least $1\frac{11}{12}$ ounces each, and U. S. Certified eggs must weigh at least $1\frac{11}{12}$ ounces each and average at least 24 ounces per dozen. U.S.R.O.P. hatching eggs must weigh at least 2 ounces each and 25 ounces or more per dozen. A number of the U.S.R.O.P. flock owners are also selecting breeders on the basis of interior quality of the eggs laid.

PULLORUM CONTROL

Pullorum control and eradication are a most important part of the National Poultry Improvement Plan. The plan provides for the control of this disease only, since it is the one disease that is known to be transmitted from the hen to the baby chick through the egg. Furthermore, the losses among baby chicks from pullorum disease may be satisfactorily controlled through the testing of breeding birds by one of the agglutination tests, removing reactors, and using sanitary methods in the operation of hatcheries.

Any one of three methods may be used in officially testing chickens for pullorum disease: (1) the standard tube-agglutination test (2) the stained antigen, rapid, whole-blood test and (3) the rapid serum test. During 1938 the rapid, whole-blood test was the most popular, being used exclusively in 21 of the 37 States doing official pullorum testing under the plan. The tube-agglutination test was used exclusively in 7 States and the rapid serum test in 3 States. Two States used all three tests, 3 States the rapid whole-blood and tube tests, and 1 State the rapid whole-blood and serum tests.

Three progressive pullorum-control classes are proved in the national plan, namely, U. S. Pullorum-Tested, U. S. Pullorum-Passed, and U. S. Pullorum-Clean. In the U. S. Pullorum-Tested class not more than 10 percent of reactors may be in the flock at the time of the last test, and these reactors must be removed from the premises of the flock owner before eggs are saved for hatching purposes.

Flocks tested by an official tester and containing no reactors on the last test made within the testing year preceding the date of sale of hatching eggs, baby chicks, and breeding stock, are given the rating of U. S. Pullorum-Passed. To qualify as U. S. Pullorum-Clean, the flock must contain no reactors in either of two consecutive tests not less than 6 months apart.

Chick losses from pullorum disease are frequently as high as 25 to 50 percent when no pullorum-control program is followed. Records are available from several sources showing losses of less than 3 percent during the first 3 weeks of brooding when an effective pullorum-control program is carried out.

Although the national plan permits carrying on the breeding and pullorum-control work independently, it is recommended that pullorum control be required for participation in the breeding stages; during 1938, 20 official State agencies made this a requirement. Similarly, 21 official State agencies required breed improvement for participation in the pullorum-control work.

INSPECTION AND SUPERVISION

Official inspection and supervision are an integral part of poultry-improvement work under the National Poultry Improvement Plan. An effort is made to keep inspection work to a minimum so it will not be burdensome in cost and yet extensive enough to assure compliance with the provisions of the plan and thus protect both producers and purchasers.

The greater part of the selecting and testing work is actually done by hatcherymen or their employees who have taken a course of training in standard-bred and production judging and pullorum testing prescribed by the State college of agriculture, and have been authorized by the official State agency to do flock-selecting and pullorum-testing work. During 1938, a total of 1,127 flock-selecting agents in 26 States were engaged part of the time in selecting birds for breeding flocks in the U. S. Approved, U. S. Verified, and U. S. Certified breeding stages; 765 pullorum-testing agents and 141 official pullorum testers were engaged in testing breeding flocks for pullorum disease. All the work of these persons is subject to inspection and approval by official State inspectors, and 138 such inspectors were employed on either a full- or part-time basis during 1938. U. S. Approved hatcheries are required to be inspected at least once during the hatching season, and U. S. Verified and U. S. Certified hatcheries are inspected at least twice during the hatching season. An R.O.P. inspector is required to spend a full day in each U.S.R.O.P. flock at least seven times during the year.

It may be of interest to know something about the Federal personnel engaged in the administration of the national plan. In the Federal Bureau of Animal Industry, three poultry coordinators devote full time to Federal administration. The senior poultry geneticist advises regarding the development and administration of the breeding phases of the plan, and other members of the Bureau of Animal Industry, particularly in the Animal Husbandry Division, serve in an administrative and advisory capacity. Specialists of the Pathological and Biochemic Divisions of the Bureau also serve in an advisory capacity in the pullorum-control phases of the plan, make field observations on methods used in conducting tests for pullorum disease, and examine samples of stained antigen for use in conducting the rapid whole-blood test. A number of other Federal agencies, such as the Agricultural Extension Service, the Press Service, and the Radio Service of the United States Department of Agriculture, and the Office of Vocational Agriculture of the United States Department of the Interior, assist in the distribution of educational and public relations material.

PARTICIPATION DURING FIRST THREE YEARS

Since the National Poultry Improvement Plan is based on tried breeding and pullorum-control practices and since it is obviously to the advantage of the poultry industry to have a coordinated national program of poultry improvement with uniform terminology rather than independent State programs with conflicting terminology, the extent of participation is one of the best measures of the value of the program.

There has been a steady and very satisfactory increase in participation each year since the plan has been in operation, as shown by table 2. The number of participating States increased from 34 in 1936 to 42 in 1938. At the present writing (March 31, 1939) breeders and hatcherymen in 43 States are cooperating in this national program in which participation is entirely voluntary.

There were 1,478 breeder and commercial hatcherymen participating in the plan during 1938, and the hatching-egg capacity of these hatcheries totaled more than 60,500,000 eggs. These figures represent 16.3 percent of the hatcheries and 26.7 percent of the hatching-egg capacity in the cooperating States.[2] Hatching eggs for these hatcheries were obtained from 28,820 flock owners who followed the provisions of the plan in selecting and testing nearly 6,000,000 breeding birds.

There were 298 poultry breeders in 33 States who were trap-nesting 108,183 birds under official supervision in conformity with the provisions of the plan in 1938. These poultry breeders had 1,966 individual male matings involving a total of 26,135 females. The males in these matings were from eggs weighing an average of at least 24 ounces per dozen during the first laying year. It is estimated that these poultry breeders could produce approximately 183,000 pedigreed males, or enough to mate with one-half of all National Poultry Improvement Plan breeding flocks, if all were used for this purpose.

Officials in the United States Department of Agriculture have been well pleased with the manner in which official State agencies and industry members have cooperated to assure the success of the National Poultry Improvement Plan. Official State agencies have shown an eagerness to develop the most effective State programs in line with the provisions of the plan, and industry members for the most part have shown a desire to comply with the provisions of the plan in every respect. State colleges of agriculture, State departments of agriculture, and livestock sanitary authorities have cooperated splendidly in the training of agents and inspectors and advising with official State agencies regarding the development of their poultry-improvement work. These agencies and others, such as the agricultural extension service and vocational agricultural teachers, have assisted materially in carrying on the educational work necessary in acquainting farmers and poultrymen with the provisions and terminology of the plan. As long as such cooperation exists, we can be assured that continued progress will be made under the National Poultry Improvement Plan.

TABLE 2.—*Extent and nature of participation in the National Poultry Improvement Plan during the first 3 years*

Item	Year ended June 30—		
	1936	1937	1938
	Number	*Number*	*Number*
States participating	34	41	42
Hatcheries participating	1,017	1,239	1,478
Capacity of hatcheries, eggs	38,066,000	52,591,786	60,523,222
Breeding flocks	23,813	30,558	28,820
Breeding birds	3,522,409	6,535,907	5,948,498
U.S.R.O.P. breeders	(1)	301	298
U.S.R.O.P. flocks	190	352	353
Birds entered in trap-nest flocks	66,547	112,202	108,183
U.S.R.O.P. breeding pens	(1)	1,675	1,966
Females in U.S.R.O.P. pens	8,207	22,322	26,135

[1] Complete data not available.

SUMMARY

Since July 1, 1935, the United States Department of Agriculture has been cooperating with official State agencies in the administration of the National Poultry Improvement Plan. Some of the general features of this plan are as follows:

1. The plan is Nation-wide in scope. It is entirely voluntary, and any poultry breeder or hatcheryman may participate by signing an agreement and complying with its provisions.
2. Provision is made for revising the plan every 1 or 2 years, and only those proposals that receive a majority vote of the cooperating States are considered.
3. Five progressive breeding stages and three progressive pullorum-control classes are provided.
4. Minimum requirements are established for each breeding stage and each pullorum-control class.
5. Provision is made for improvement in production qualities through selection of breeding birds on the basis of physical appearance, physio-

[2] WARREN, E. L., and WERMEL, M. T. An economic survey of the baby chick hatchery industry. U. S. Dept. Agr., A. A. A. Bull., 64 pp., illus.

logical changes, production records, pedigree, and progeny test.

6. Hatching eggs are carefully selected for size, shape, color, and freedom from tints.

7. Flocks, eggs, chicks, and hatcheries are subject to inspection at least once a year by official State inspectors who are employees of official State agencies.

8. All advertising is required to be submitted to and approved by the official State agency.

9. The official terminology of the plan applies in all parts of the country and is limited to those who are participating and complying with its provisions.

The plan is now in its fourth year of successful operation. At the present writing (March 31, 1939) breeders and hatcherymen in 43 States are cooperating in this national program. Last year 1,478 hatcheries with a hatching-egg capacity of about 60 million eggs were operated under the supervision of the plan, and more than 28,000 flock owners with approximately 6,000,000 breeding birds supplied eggs to these hatcheries. About 300 poultry breeders were trap-nesting more than 100,000 birds under U. S. Record of Performance supervision. The plan is resulting in reduced mortality among baby chicks from pullorum disease and improved quality in chicks with respect to production. Also purchasers are enabled to buy with more assurance of quality and satisfaction because of the uniform standards and terminology.

ORGANISATION UND ERFOLG DER BERATUNG VON LANDWIRTSCHAFTLICHEN UND GEFLÜGELKLEINHALTUNGEN IN DEUTSCHLAND

Von LANDWIRTSCHAFTS-ASSESSOR J. MÜNICHSDORFER, *Hauptgeschäftsführer des Reichsverbandes Deutscher Kleintierzüchter, Berlin, Deutschland*

Der Geflügelbestand Deutschlands, der im Jahre 1912 noch rund 72 Millionen Stück betrug, hat in den folgenden Kriegs- und Inflationsjahren eine starke Abnahme erfahren und wies 1922 den Tiefstand von 65 Millionen Stück auf. Dann erfolgte ein verhältnismässig rascher Aufschwung, der als Ursache ein günstiges Verhältnis zwischen Eier-Futterpreis hatte und somit die Gründung von selbständigen Geflügelfarmen stark förderte. Diese Entwicklung musste aber in dem Augenblick nicht nur eine Unterbrechung sondern einen Rückschlag erleiden, als die Preise für das Getreide erhöht wurden, und das trat im Jahre 1930/31 ein. Während der Bestand an Federvieh 1930 noch den bisher nicht wieder erreichten Höchststand von 98,2 Millionen aufwies, fiel er 1930 auf 93,2 Millionen. Damit bestätigte sich das betriebswirtschaftlich als richtig erkannte Gesetz, dass ein landwirtschaftlicher Spezialzweig eine gesunde Wirtschaftlichkeit nur in einem vielseitigen landwirtschaftlichen Betriebe haben kann.

Es entstanden somit neue Aufgaben für die Förderung der Geflügelwirtschaft, um das Ziel, die Eiererzeugung soweit zu steigern, dass der Inlandsbedarf möglichst gedeckt wird, schneller, sicherer und ohne Rückschläge zu erreichen.

Zwei Wege sind seit der nationalsozialistischen Revolution im Jahre 1933 eingeschlagen worden, die Deutschland dem Ziel näher gebracht haben. Aus den gesunden Farmbetrieben sind Zuchtbetriebe geschaffen worden, deren Aufgabe es ist, die breite Landesgeflügelhaltung mit hochwertigem, leistungsstarkem Tiermaterial zu versorgen. Die landwirtschaftlichen Geflügelhöfe aber mit rund 80 v. H. des gesamten Geflügelbestandes mussten von ihrer schlechten Betriebsweise auf eine sachgemässe Haltung, neuzeitliche Fütterung und die Einstellung von Leistungstieren umgestellt werden.

Da die landwirtschaftlichen Betriebe in den früheren Jahren bei den geringen Eierpreisen aus ihrem Hühnerhofe keinen Gewinn erzielten und aus einem gewissen Vorurteil wurde die Hühnerhaltung stark vernachlässigt. Wollte man in der bäuerlichen Geflügelhaltung vorankommen, so musste zunächst ein gerechter Preis für die Eier geschaffen werden. Darüberhinaus musste dem Landwirt aber auch die Abnahme seines Eieranfalles gesichert werden, so vor allen Dingen während der sogenannten Eierschwemme. Diese Voraussetzungen konnten durch die Marktordnung erfüllt werden.

Nun galt es, dem Bauern den Anstoss zur Umstellung seines vernachlässigten Hühnerhofes auf eine sachgemäss geführte Geflügelhaltung zu geben.

In allen Zweigen der Landwirtschaft ist man in Deutschland schon seit geraumer Zeit zur praktischen Hofberatung übergegangen, da nur sie den vollen Erfolg bringt. So war auch in der Geflügelhaltung der Hebel bei der praktischen Beratung anzusetzen.

Versuchsweise wurden in wenigen Gebieten des Reiches einzelne Geflügelzuchtberater eingesetzt, um die Auswirkung dieser Tätigkeit feststellen zu können. Der Erfolg dieser Massnahme war über Erwarten gut. Deshalb erfuhr die Beraterarbeit von Jahr zu Jahr eine Verbreiterung. Hierbei leitete der Gedanke, der für die ganze Arbeit richtunggebend ist:

1) bei der Förderung der bäuerlichen Geflügelhöfe sind in erster Linie die Gebiete zu berücksichtigen, die nach ihrer landwirtschaftlichen Struk-

tur und Betriebsweise in der Lage sind, den Leistungsgedanken schnellstens und mit größtem Erfolg in die Tat umzuseten;

2) den Arbeitskreis der Berater nicht zu weit zu ziehen, um eine erfolgreiche Tätigkeit zu gewährleisten;

5) eine planmässige Beratung von Hof zu Hof und von Dorf zu Dorf durchzuführen;

4) in den einzelnen Dörfern geeignete fachkundige und interessierte Hühnerhalter heranzubilden, die als Stützpunkt der Beratungsstelle innerhalb ihrer Dorfgemeinschaft die einzelnen landwirtschaftlichen Geflügelhalter betreuen. Dadurch erfährt die Beratung eine Entlastung und die Möglichkeit zur Erweiterung des Arbeitsfeldes und

5) auch die beratenen Geflügelhöfe dauernd zu überwachen und zu betreuen, da nur der fortwährende Anstoss einen bleibenden Erfolg sichert.

Nach diesen Gesichtspunkten ist der Aufbau der Geflügelzuchtberatung für den bäuerlichen Hühnerhalter in den Jahren von 1933 bis 1937 erfolgt. 1933 sind 9 Beratungsstellen eingerichtet worden, 1934 wurden sie auf 30 erhöht, 1935 waren 71 Geflügelzuchtberatungskräfte tätig, 1936 steigerte sich ihre Zahl auf 116 und im Jahre 1937 ist das Beraternetz auf 200 Stellen für das Altreich erweitert worden. Diese Zahl von 200 Beratungsstellen soll für die Zukunft beibehalten werden. Durch die Eingliederung Österreichs und des Sudentenlandes ist ein weiterer Ausbau des Beraternetzes erfolgt und bereits abgeschlossen. In diesen Gebieten sind, der Bedeutung der Geflügelhaltung entsprechend, 40 Beratungsstellen eingerichtet worden.

Die Arbeit einer Beratungskraft erstreckt sich auf den Bereich von drei Kreisbauernschaften. Der Berater ist der zuständigen Landesbauernschaft, der provinziellen Gliederung des Reichsnährstandes, unterstellt und wird örtlich entweder von einem Tierzuchtamt, einer Kreisbauernschaft oder einer Landwirtschaftsschule überwacht. Schon nach verhältnismässig kurzer Zeit ist die Arbeit der Berater derart gewachsen, dass diese nicht mehr in der Lage waren, bei Benutzung eines Fahrrades oder der öffentlichen Verkehrsmittel ihren Aufgaben nachzukommen. Aus diesem Grunde wurden die sämtlichen Beratungsstellen im Jahre 1937 mit einem Kraftwagen ausgestattet, der es ermöglicht, die gestellten Aufgaben zu meistern.

Voraussetzung für die Zulassung zu einem Beraterlehrgang, den jede Beratungskraft mit Erfolg abgeschlossen haben muss, ist eine geregelte Fachausbildung. Diese umfasst 2 Lehrjahre mit dem Abschluss der Prüfung für den Geflügelzuchtgehilfen. Darüberhinaus wird eine mehrjährige praktische Tätigkeit in Geflügelzuchten gefordert und ein Mindestalter von 22 Jahren. Jüngere Kräfte dürften sich im allgemeinen für diesen Beruf nicht eignen, weil der Bauer von zu jungen Menschen kaum Ratschläge entgegennimmt. In einem achttägigen Ausbildungslehrgang werden die Geflügelzüchter auf ihre Eignung für die Beratungstätigkeit geprüft. Sie müssen neben dem Fachwissen eine gewisse Gewandheit im Auftreten und im Umgang mit Menschen besitzen. Nach Abschluss dieses Lehrganges werden sie einem alten bewährten Berater für einen halben oder einen ganzen Monat zum Einarbeiten zugewiesen. Wenn sie allen Anforderungen gerecht geworden sind, kann ihre Anstellung als Beratungskraft erfolgen.

Die Tätigkeit der Geflügelzuchtberater wird durch eine Reihe von Förderungsmassnahmen des Reiches unterstützt. So werden beim Stallbau nach bestimmten Grundsätzen Beihilfen gewährt, auch bei der Anschaffung von Eintagsküken und Junghennen, die aus anerkannten Vermehrungszuchten bezogen werden, gibt es Reichszuschüsse. Um der Überalterung der Tierbestände vorzubeugen, werden die Jungtiere mit geschlossenen Fußringen versehen, so dass der Bauer die Möglichkeit hat, nach 2 oder 3 Jahren die älteren Tiere herauszufinden und auszumerzen. Obwohl das Ziel der Aufklärungsarbeit dahin geht, den landwirtschaftlichen Geflügelhalter im allgemeinen nicht mit Zuchtaufgaben zu belasten, war es dennoch notwendig, Betriebe, die sich von einer falschen eigenen Zucht nicht abbringen lassen, zu einer Leistungssteigerung anzuhalten. Dies geschieht in der Weise, dass die bäuerlichen Hühnerzüchter einen Zuchthahn gegen Abgabe eines eigenen Hahnes kostenlos erhalten.

In den vielen hunderttausend Geflügelkleinhaltungen—Siedler, Kleingärtner, städtische Geflügelzüchter—liegen noch grosse Reserven, weil sie nicht genügend über die sachgemässe Haltung und Pflege des Geflügels unterrichtet sind. Diese Reserven mobil zu machen, ist eine überaus wichtige und erfolgreiche Aufgabe. Zu ihrer Durchführung bedient sich das Reich und der Reichsnährstand der Reichsfachgruppe Ausstellungsgeflügelzüchter e. V. im Reichsverband Deutscher Kleintierzüchter e. V. Diese Reichsfachgruppe umfasst 24 Landesfachgruppen mit über 400 Kreisfachgruppen, die örtlich über 4000 Vereine aufweisen. Insgesamt sind in dieser Teilorganisation des Reichsverbandes Deutscher Kleintierzüchter 135 000 Einzelmitglieder zusammengeschlossen. Der Reichsfachgruppe Ausstellungsgeflügelzüchter e. V. ist die Aufgabe gestellt, die Beratung in erster Linie auf die folgenden Gebiete zu lenken: sachgemässe Unterbringung und Haltung des Geflügels, neuzeitliche Fütterung unter besonderer Berücksichtigung der Abfälle von Haus und Garten und Einstellung von Leistungstieren.

In 5 Lehrgängen wurden rund 500 Mitarbeiter der Reichsfachgruppe und der 24 Landesfachgruppen mit den Richtlinien vertraut gemacht und für die Durchführung der weiteren Ausbildungsarbeit ausgerichtet. Anschliessend sind rund 4000 Mitarbeiter der Kreisfachgruppen und ebensoviel der Vereine geschult worden. Sie alle zusammen gehen nunmehr in die einzelnen Kleinhaltungen und zeigen am praktischen Beispiel die notwendigen Verbesserungen, die zu einer Leistungssteigerung führen. Auch dieser Kreis der Geflügelkleinhalter erfährt seitens des Staates eine besondere Förderung. Sie besteht, wie bei dem landwirtschaftlichen Geflügelhof in der Gewährung von Beihilfen beim Ankauf von Eintagsküken und Junghennen, die aus anerkannten Vermehrungszuchten stammen müssen, durch Zuschüsse beim Stallbau und beim Bezug von geschlossenen Fußringen, die zum Zwecke der Alterskennzeichnung angelegt werden.

Welche Erfolge durch den Einsatz der hauptamtlichen und ehrenamtlichen Beratung erzielt wurden, soll mit einigen Zahlen wiedergegeben werden: 200 Geflügelzuchtberater haben in 2 Jahren und zwar 1937 und 1938 in 200 000 bäuerlichen Geflügelhöfen Einzelberatungen durchgeführt und dabei 8 Millionen Legehennen erfasst. In diesen Betrieben sind über 40 000 Hühnerställe gebaut und 30 000 Kükenheime oder künstliche Glucken beschafft worden. An die beratenen Geflügelhöfe sind in den 2 Jahren über 6 Millionen Eintagsküken oder Junghennen aus anerkannten Vermehrungszuchten verbilligt abgegeben worden Der Einsatz der 10 000 ehrenamtlichen Geflügelzuchtberater hat es möglich gemacht, dass in rund 500 000 Geflügelkleinhaltungen Beratungen durchgeführt werden konnten. Sie haben erreicht, dass über 30 000 Stallungen umgebaut wurden und in etwa 10 000 Betrieben künstliche Glucken angeschafft worden sind.

Der Erfolg des Einsatzes der hauptamtlichen und ehrenamtlichen Geflügelzuchtberater geht eindeutig aus dem Ergebnis der Viehzählung vom Dezember 1938 hervor, wonach sich der gesamte Hennenbestand von 83 Millionen Stück auf Althennen mit 42,5 und Junghennen mit 30,5 Millionen verteilt. Somit konnte in den letzten Jahren der Geflügelbestand Deutschlands vom vierjährigen Umtrieb auf einen dreijährigen gebracht werden.

ZUSAMMENFASSUNG

In den Nachkriegsjahren wurde durch ein günstiges Verhältnis zwischen Eier und Futterpreis die Gründung selbständiger Geflügelfarmen stark gefördert. Diese Betriebsform hat sich für Deutschland als falsch erwiesen. Deshalb sind seit der Machtübernahme durch den Nationalsozialismus im Jahre 1933 2 neue Wege eingeschlagen worden, die das Ziel der Leistungssteigerung schneller erreichen lassen. Aus den gesunden Farmbetrieben sind Zuchtbetriebe geschaffen worden, deren Aufgabe in der Lieferung von Leistungstieren für die breite Landesgeflügelhaltung besteht. Die landwirtschaftlichen Geflügelhöfe mit rund 80 v. H. des gesamten Tierbestandes müssen auf eine gesunde Haltung, sachgemässe Fütterung und die Einstellung von Leistungstieren umgestellt werden.

Den Anstoss zur Verbesserung der vernachlässigten landwirtschaftlichen Hühnerhaltung gibt der Geflügelzuchtberater, dessen Aufgabe darin besteht, den bäuerlichen Geflügelhalter auf seinem Hof zu beraten. In Deutschland bestehen 240 Beratungsstellen, die dem Reichsnährstand unterstellt sind. Die Tätigkeit üben Geflügelzüchter aus, die vor ihrer Anstellung in einem Beraterlehrgang auf ihre Eignung geprüft werden. Eine Reihe von Förderungsmassnahmen des Reiches unterstützt die Arbeit der Beratungskräfte. Von diesen sind u. a. zu nennen: die Gewährung von Beihilfen bei der Beschaffung von Eintagsküken und Junghennen aus anerkannten Vermehrungszuchten, Verbilligungszuschüsse für den Stallbau und verbilligte Abgabe von geschlossenen Fußringen zur Alterskennzeichnung der Tiere.

Neben den landwirtschaftlichen Geflügelzüchtern bestehen hunderttausende von Geflügelkleinhaltungen, die ebenfalls einer Umstellung dringend bedürfen. Diese Aufgabe hat sich der Reichsverband Deutscher Kleintierzüchter, Reichsfachgruppe Ausstellungsgeflügelzüchter e. V. gestellt. Etwa 10.000 Mitarbeiter dieser Reichsfachgruppe, die in Ausbildungslehrgängen über die Erfordernisse der Leistungssteigerung der Geflügelkleinhaltungen unterrichtet wurden, zeigen am praktischen Beispiel bei den einzelnen Kleinhaltern die notwendigen Verbesserungen, die zu einer Leistungssteigerung führen. Auch diesen Betriebszweig fördert der Staat durch Beihilfen beim Ankauf von Eintagsküken und Junghennen durch Zuschüsse beim Stallbau und beim Bezug geschlossener Fußringe.

Die Erfolge, die durch den Einstaz der hauptamtlichen und ehrenamtlichen Berater erzielt wurden, sind: 200 hauptamtliche Geflügelzuchtberater haben in 2 Jahren (1937 und 1938) in 200.000 bäuerlichen Geflügelhöfen Einzelberatungen durchgeführt und dabei 8 Millionen Legehennen erfasst.

Der Einsatz der 10.000 ehrenamtlichen Geflügelzuchtberater hat es möglich gemacht, dass rund 500.000 Geflügelkleinhaltungen betreut werden konnten.

SUMMARY

During the postwar years the establishment of independent poultry farms was greatly encouraged through a favorable relation between egg and feed prices. However, this form of enterprise proved unsuitable to conditions prevailing in Germany. Therefore, since the coming into power of national socialism in 1933, two ways have been followed which will lead more quickly to the goal of increased production. Out of sound farm enterprises, breeding stations were created, whose task it is to supply the country's poultry industry in general with birds of good production records. The agricultural poultry farmers, with about 80 percent of the entire poultry stock, needed to be educated to the sanitary care, proper feeding, and acquisition of productive stock.

The impetus for the improvement of neglected agricultural poultry keeping is furnished by poultry-breeding advisers whose task it is to give advice to the agricultural poultry keeper on his premises. There are 240 advisory agencies in Germany which are responsible to the organization of the Reich Food Estate (Reichsnährstand). This advisory work is carried out by poultry breeders who, before their appointment, are examined as to their qualifications during a course for advisers. A series of promotive measures of the Reich supports the work of the advisory personnel. Some of these measures are: The granting of subsidies for the purchase of day-old chicks and pullets, contributions to the building of poultry houses, and the sale at reduced prices of closed leg bands for recording the age of the birds.

Besides the agricultural poultry breeders there are hundreds of thousands of small-scale poultry keepers in need of education with respect to breeding and keeping of poultry. This task has been assumed by the technical group of exhibition breeders, which is a subdivision of the National Union of German Small Stock Breeders. About 10,000 collaborators of this technical group, who in special courses received instruction on the requirements for an increase in the production of small-scale poultry keeping, are demonstrating to the individual small-scale poultry keepers, with practical examples, the improvements necessary for increased production. This type of establishments also enjoys governmental aid in the form of subsidies for the purchase of day-old chicks and pullets, and contributions to the building of poultry houses and to the purchase of closed leg bands.

The results obtained through the employment of professional and voluntary advisers are as follows: In two years (1937 and 1938) 200 professional poultry-breeding advisers gave individual advice on 200,000 peasant poultry farms representing a total of eight million laying hens.

The employment of 10,000 voluntary poultry-breeding advisers made it possible to take care of about 500,000 small-scale poultry keepers.

ORGANISATION UND KONTROLLE DES ZUCHTWESENS—REICHSGEFLÜGELHERDBUCH, VERMEHRUNGSZUCHT, BRUTEIERLIEFERBETRIEB

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Den verantwortlichen Stellen im neuen, nationalsozialistischen Deutschland war von Beginn an klar, dass der Neuaufbau der deutschen Geflügelwirtschaft nur möglich war mit einer einheitlichen, straffen, auf dem Führerprinzip aufgebauten Organisation. Diese wurde im Reichsverband deutscher Kleintierzüchter unter dem Präsidenten Herrn Karl Vetter geschaffen.

Entgegen der früher geübten Praxis, die Zucht sich selber zu überlassen, erfolgte im Jahre 1933 die vollkommen einheitliche Ausrichtung des Zuchtwesens in der deutschen Geflügelwirtschaft für das ganze Reich. Grundlegend neu war die Abstellung aller Massnahmen auf die Versorgung der ländlichen und bäuerlichen Geflügelhaltung mit leistungsfähigen Legetieren, die nur aus kontrollierten, anerkannten Zuchten mit Reichsbeihilfen abgegeben werden. Um mühevolle Zuchtarbeit nicht zu zersplittern, kamen nur vier Rassen zur Anerkennung.

1. weisse Leghorn
2. rebhf. Italiener
3. rote Rhodeländer
4. weisse Wyandotten

Die gesamte deutsche Geflügelwirtschaft stützt sich auf drei Hauptpfeiler:

1. die Reichsgeflügelherdbuchzuchten
2. die anerkannten Vermehrungszuchten
3. die ländliche und bäuerliche Geflügelhaltung

Das Reichsgeflügelherdbuch ist eine Einrichtung der Reichsfachgruppe Landwirtschaftliche Geflügelzüchter e. V. im Reichsverband Deutscher Kleintierzüchter e. V. und umfasst alle deutschen Geflügelherdbuchzuchten. Es untersteht dem Präsidenten der genannten Reichsfachgruppe. Dem Reichsgeflügelherdbuch ist die Aufgabe gestellt, den deutschen Geflügelbestand in seinen Leistungsanlagen so zu verbessern, dass unter Verwendung möglichst wirtschaftseigener Futtermittel die Versorgung des deutschen Volkes mit eigenen Geflügelerzeugnissen gewährleistet wird.

Um diese Aufgabe erfüllen zu können,

werden 1. alle Geflügelherdbuchzuchten organisatorisch zusammengefasst,

wurde 2. eine Zuchtordnung mit Vorschriften für die Herdbuchführung herausgegeben,

werden 3. die Geflügelherdbuchzuchten ständig überwacht und in allen züchterischen Angelegenheiten beraten.

In die Arbeitsgemeinschaft aller Hochleistungszüchter, die im Reichsgeflügelherdbuch zusammengeschlossen sind, können nur Züchter aufgenommen werden, die persönlich in gutem Ansehen stehen, kaufmännisch einwandfrei sind und die sich in einer mindestens vierjährigen Anwärterzeit als Züchter ausreichend bewährten. Züchter welche während dieser Zeit die ihnen auferlegten Pflichten nicht ordentlich oder pünktlich erfüllten, können in das Reichsgeflügelherdbuch nicht aufgenommen werden. Die Anerkennung ist also in besonderem Masse auf die Person abgestellt.

Der Betrieb des Herdbuchzüchters muss den Bestimmungen des Reichsnährstandes über die Anerkennung von Vermehrungszuchten für Hühner ensprechen, das heisst:

1. Die Ställe müssen hell und trocken sein,
2. sie dürfen im Allgemeinen nicht mehr als drei Tiere je qm Grundfläche beherbergen,
3. es sollen wenigstens 10 qm Auslauf je Henne und ausserdem genügend Aufzuchtgelände vorhanden sein,
4. die Zuchttiere müssen den vorgeschriebenen geschlossenen Fussring tragen,
5. Fallennesterkontrolle muss durchgeführt werden.

Darüber hinaus wird das Vorhandensein einer einwandfreien Einzelschlupfvorrichtung verlangt.

An die Herdbuchtiere werden hohe Anforderungen vor allem in Bezug auf Lebenskraft und Gesundheit gestellt. Der Reichsgeflügelgesundheitsdienst wacht amtlicherseits über die auschliesliche Verwendung lebenskräftiger, gesunder Elterntiere.—An die Legeleistung der Zuchttiere und ihrer weiblichen Vorfahren werden gleichfalls hohe Anforderungen gestellt, die als Ziel nicht einzelne hohe Spitzenleistungen sind, sondern übernormal gute Herdendurchschnittsleistungen. Dabei sind Dauerleistungen sehr erwünscht.—Eine Henne, welche zur Zucht zugelassen werden soll, muss mindestens 175 Eier oder 9000 Gramm Eimasse gelegt haben. Die gleichen Mindestleistungen müssen von ihren weiblichen Vorfahren in wenigstens zwei Generationen erreicht worden sein. Von den Zuchthähnen werden, abgesehen von der hier fortfallenden Eierleistung die gleichen Vorfahrenleistungen weiblicherseits in mindestens zwei Generationen verlangt.

In der Zuchtbuchführung werden nur solche Aufzeichnungen anerkannt, die amtlicherseits durch das Reichsgeflügelherdbuch laufend kontrolliert wurden. Jeder Herdbuchzüchter und Anwärter ist deshalb verpflichtet, laufend alle Herdbuchaufzeichnungen an die zuständige Landesgeschäftsstelle des Reichsgeflügelherdbuches einzusenden. Private Zuchtaufzeichnungen haben keine Gültigkeit und werden nicht anerkannt.

Um den einwandfreien Nachweiss der Abstammung der Nachzucht von bestimmten Elterntieren zu erbringen, muss jeder Herdbuchzüchter nach Beendigung jeder Brut eine sogenannte Brutliste an die Landesgeschäftsstelle des Reichsgeflügelherdbuches einreichen aus welcher die jeweils geschlüpften Herdbuchküken der einzelnen Zuchthennen ersichtlich sind. Jedes Küken erhält sofort nach dem Schlupf eine Kükenmarke angelegt, welche nur einmal verwendbar ist und auf welcher der Jahrgang sowie die laufende Nummer verzeichnet sind. Am Schluss der gesamten Brutsaison besteht also in in einer Landesgeschäftsstelle des Reichsgeflügelherdbuches die Möglichkeit nachzuprüfen, wieviel Nachkommen jede Henne der einzelnen Züchter hatte und mit welchen Kükenmarken dieselben versehen wurden. So ist auch hier eine einwandfreie Kontrolle gegeben.

Während die weiblichen Nachkommen ab 1. Oktober des Schlupfjahres einer einjährigen Vorkontrolle unterworfen werden um erst den Nachweiss zu erbringen, dass die erwähnten Mindest-Legeleistungen erfüllt wurden, werden die Hähne im Mindestalter von 5 Monaten einer aus vier Personen bestehenden Körkommision vorgestellt, welche darüber entscheidet, ob die einzelnen Tiere zur Zucht zugelassen werden oder nicht. Die zugelassenen Zuchthähne kommen dann im Herbst entweder zur Zuchthähneversteigerung oder werden direkt ab Hof des Züchters verkauft. So dienen die Reichsgeflügelherdbuchzuchten als Hochzuchten in erster Linie dazu, hochwertiges Zuchthähnematerial herauszuzüchten, welches möglichst sicher in der Lage ist die guten Eigenschaften seiner Vorfahren bezüglich Legeleistung, Schlupffähigkeit, Frohwüchsigkeit, Gesundheit u.s.w. weiter zu vererben. Diese Herdbuchhähne gehen nicht direkt in die ländlichen und bäuerlichen Geflügelhaltungen. Sie werden vielmehr vornehmlich von dem vom Reichsnährstand anerkannten Vermehrungszuchten gekauft, da diese auf Grund der für sie geltenden Bestimmungen verpflichtet sind nur zur Zucht zugelassene Herdbuchhähne einzustellen. Die Vermehrungszüchter sind nun verpflichtet, den Herdbuchhähnen nur Hennen anzupaaren, welche im ersten Legejahre mindestens 140 Eier gelegt haben. Die grosse Zahl der Vermehrungszuchten, welche vom Reichsnährstand anerkannt sind, haben nun die Aufgabe die grosse Masse der ländlichen und bäuerlichen Geflügelhaltungen mit leistungsfähigen Eintagsküken und Junghennen zu versorgen. Da diese Zuchten nicht in der Lage sind den Bedarf zu decken, wurden seitens des Reichsnährstandes neue Möglichkeiten geschaffen, um für die Zukunft diejenige Menge Eintagsküken und Junghennen erzeugen zu können, welche von der Landwirtschaft verlangt wird. Es werden deshalb vom Reichsnährstand Bruteierlieferbetriebe anerkannt, welche sich meist in den Händen von Bauern und Landwirten befinden, also eine wirtschaftseigene Futtergrundlage haben. Sie sind dazu bestimmt, der überwachenden Vermehrungszucht zusätzlich Bruteier zu liefern. Da der Bruteierlieferbetrieb verpflichtet ist, seine Nachzucht von der überwachenden Vermehrungszucht zu beziehen, hat er ungefähr das gleiche Zuchttiermaterial laufen wie die Vermehrungszucht, welche von ihm die Bruteier bezieht. Auch die Lieferbetriebe müssen Herdbuchhähne einstellen. Die Bruteierlieferbetriebe stellen also sozusagen Zweigbetriebe der Vermehrungszuchten dar.

Sowohl die Vermehrungszuchten wie auch die Bruteierlieferbetriebe unterstehen dem Reichsgeflügelgesundheitsdienst.

Durch planmässige Zusammenarbeit von Herdbuch- und Vermehrungszuchten wurde es möglich der breiten Landesgeflügelhaltung eine Nachzucht zur Verfügung zu stellen, mit welcher entsprechende Mehrleistungen erzielt wurden. Dabei wird auch hier weniger Wert auf einzelne hohe Spitzenleistungen gelegt, als auf gute Herdendurchschnittsleistungen.

Um eine einwandfreie Durchführung und Beachtung der Bestimmungen des Reichsgeflügelherdbuches, sowie des Reichsnährstandes über die Anerkennung von Vermehrungszuchten für Hühner und von Bruteierlieferbetrieben zu sichern, wurden in den einzelnen Bereichen der Landesfachgruppen der Reichsfachgruppe Lamdwirtschaftliche Geflügelzüchter e. V. Kontrollorgane eingerrichtet. Für die Herdbuchzuchten sind es die Herdbuchgeschäftsfühner und die aus vier Personen bestehenden Körausschüsse, für die Vermehrungszuchten die ebenfalls aus vier Personen bestehenden Anerkennungsausschüsse. Zwischen den Mitgliedern eines Körausschusses und des Anerkennungsausschussses besteht meist Personalunion.

In den Ausschüssen sind vertreten:

zwei praktische Herdbuch- bzw. Vermehrungszüchter,

der Kleintierzucht-Sachbearbeiter der Landesbauernschaft,

der Vertreter des Reichsgeflügelgesundheitsdienstes.

Diese Kontrollorgane haben das Recht Einsicht zu nehmen in die gesamte Betriebsführung, insbesondere auch in die Zucht- und Geschäftsbuchführung. Ihre Tätigkeit wird von allen reell arbeitenden Zuchten nicht als Kontrolle, sondern mehr als Beratung und Betreuung empfunden. Durch eine für das gesamte grossdeutsche Reich vorgeschriebene einheitliche Zuchtbuchführung sind die Mitglieder der Kontrollorgane in der Lage, sich leicht und schnell einen Einblick in den einzelnen Zuchtbetrieb zu verschaffen.

Eine Kontrolle darüber, ob die vom Reichsnährstand anerkannten Vermehrungszuchten wirklich nur einwandfreie, leistungsfähige Eintagsküken und Junghennen an die ländlichen und bäuerlichen Geflügelhaltungen abgeben, ist durch den Einsatz von ca. 250 motorisierten, hauptamtlich tätigen Geflügelzuchtberatern und -Beraterinnen möglich, die nach den Anweisungen des Kleintierzucht-Sachbearbearbeiters der Landesbauernschaften arbeiten und im Anerkennungs- und Kör-Ausschuss vertreten sind.

Die Erfahrungen welche in Deutschland mit der Organisation und Kontrolle in der geschilderten Art und Weise gemacht wurden, sind ausserordentlich gute. Sie trugen dazu bei, in grossem Umfange leistungsfähige Hennen anerkannter Rassen auf die Bauernhöfe zu bringen und die Geflügelbestände zu verjüngen.

ZUSAMMENFASSUNG

Die Organisation und Kontrolle des Zuchtwesens in Grossdeutschland liegt in den Händen der Reichsfachgruppe landwirtschaftliche Geflügelzüchter im Reichverband Deutscher Kleintierzüchter e. V. Es erfolgte eine vollkommen einheitliche Ausrichtung des Zuchtwesens in der Geflügelwirtschaft für das ganze Reichsgebiet. Alle Massnahmen sind abgestellt auf die Versorgung der ländlichen und bäuerlichen Geflügelhaltung, als Haupterzeuger von Eiern, mit leistungsfähigen Legetieren, die nur aus kontrollierten, anerkannten Zuchten mit Reichsbeihilfen abgegeben werden. Für die organisierte Zucht wurden nur vier Rassen anerkannt, nämlich weisse Leghorn, rebhf. Italiener, weisse Wyandotten und rote Rhodeländer.

Die drei Hauptpfeiler der deutschen Geflügelwirtschaft sind:

1. die Herbuchzuchten (Hochzuchten)
2. die anerkannten Vermehrungszuchten, diesen angeschlossen die Bruteierlieferbetriebe
3. die ländliche und bäuerliche Geflügelhaltung.

An die Züchter, die Betriebseinrichtungen und die Zuchttierbestände aller anerkannten Betriebe werden hohe Anforderungen gestellt, um nur wirklich einwandfreie, gesunde, lebenskräftige und leistungsfähige Nachzucht für die ländliche und bäuerliche Geflügelhaltung bereit stellen zu können.

Die Kontrolle wird durch praktische Züchter, Vertreter des Reichsgeflügelgesundheitsdienstes und den Beamten des Reichsnährstandes zur Zufriedenheit aller Beteiligten durchgeführt.

Innerhalb von fünf Jahren gelang es der organisierten Zucht im Verein mit dem Beratungswesen, die deutschen Geflügelbestände erheblich zu verjüngen und in grossem Umfange leistungsfähige Hennen auf die Bauernhöfe zu bringen.

SUMMARY

The organization and control of poultry breeding in greater Germany lies in the hands of the technical group of agricultural poultry breeders, which is a subdivision of the National Union of German Small Stock Breeders. A Nation-wide reorganization of breeding activities was undertaken along strictly uniform lines. The purpose of all these measures is the supply of rural and agricultural poultry keepers, as the main producers of eggs, with productive laying hens which can be purchased with Reich subsidies from controlled and recognized breeding stations only. Only four breeds—White Leghorns, White Wyandottes, Partridge Colored Italian Fowl and Rhode Island Reds—are recognized for organized breeding.

The three main pillars of Germany's poultry industry are:

1. Breeding stations of the Reich Poultry Pedigree Register (first-class breeding stations).
2. Recognized stations for the production of breeding stock in connection with stations for the production of hatching eggs.
3. Rural and agricultural poultry keeping.

The requirements for breeders, equipment,

and stock of recognized breeding stations are high in order to guarantee the supply of good, healthy, viable, and productive stock to rural and agricultural poultry keepers.

The control is exercised to the full satisfaction of the parties concerned by practical breeders, representatives of the Reich Poultry Health Service and by officials of the Reich Food Estate (Reichsnährstand).

Within five years, in cooperation with advisory agencies, organized poultry breeding succeeded in reducing the average age of Germany's stock and in supplying farms, to a large degree, with productive hens.

EFFECT OF ENVIRONMENT ON THE EXPRESSION OF RESISTANCE AND SUSCEPTIBILITY TO DISEASE IN THE DOMESTIC FOWL

By E. Roberts, *Professor of Animal Genetics;* J. M. Severens, *Assistant in Animal Genetics; and* L. E. Card, *Professor of Poultry Husbandry, University of Illinois, Urbana, Illinois, U. S. A.*

Any characteristic of an individual is the result of the interaction of both environment and heredity. This concept renders useless a good deal of the discussion concerning the relative importance of environment and heredity. Yet there are genes, such as those for color, which are much less affected by a fluctuating environment than are other genes which influence such characters as milk production, egg yield, or resistance to bacterial infection.

Although characters are the end products of both environment and heredity, yet the differences among individuals of a population in the same or similar environments are due to differences in genic constitution. In this sense heredity, and not environment, is the factor responsible for the differences. Of much importance, and a phase which is too often ignored, is the relation of environment to the expression of hereditary factors or genes.

For centuries the profound effect of environmental factors on the expression of disease has been known. Hippocrates 2,400 years ago concluded that climate had a very significant relation to the expression of certain diseases, a conclusion which has recently received support. Deficiency of certain vitamins results in the well-known diseases, beri-beri and rickets, and also a lowered vitality, increasing the severity of bacterial infections. Deficiency of minerals, such as phosphorous and calcium, or the presence of others, such as selenium, may result in profound functional disorders.

A change in body temperature may be either injurious or beneficial, depending on the organism present. In the classic experiment of Pasteur, the body temperature of a bird naturally immune to anthrax was lowered until it became susceptible to infection. Also by raising the body temperature a frog may be infected with the human type of tuberculosis. Physicians report that persons changing from the temperate regions to tropics may have acute dysentery without the presence of either bacillary or amoebic organisms. Mallman, Moore, and Arnold[1] and Mallman[2] showed that lowering the brooding temperature significantly increased the mortality among chicks infected with *Salmonella pullorum.*

In general, environmental factors less than the optimum are likely to affect adversely the individual to such an extent that when it is infected the symptoms are more severe than they would be under a better environment.

The importance of this fact was brought strikingly to our attention in some of our genetic work on pullorum disease. In certain tests for resistance to this disease, in the absence of our usual chick mash, laying mash (diet B) was fed to the chicks since they were to be discarded after 21 days. Abnormally high mortality was observed among the controls, which had not been inoculated. First we looked for possible modes of infection and were unable to account for the mortality on this basis. The diagnostic report from the Animal Pathology Laboratory was: "Negative to *Salmonella pullorum* infection. No gross pathology. Gas and fluid nature of intestinal contents suggestive of feeding or management disturbance."

Chick mash (diet A) was substituted, and the high mortality among the controls was eliminated. Survival among noninoculated chicks on diet B was 71.8 percent and on diet A, 98.1 percent, whereas among inoculated chicks the percentages of survival for those on diets B and A were 19.7 and 80.5, respectively. The results of these observations are given in table 1. Carefully controlled tests were then made with both kinds of diets, and the high mortality again appeared among chicks on the laying mash (diet B), the results of which are given in table 2.

Mortality among both noninoculated and in-

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[1] Mallman, W. L., Moore, J. M., and Arnold, L. R. A study of pullorum disease in baby chicks as shown by the effect of different temperatures in brooding. Poultry Sci. 12:323. 1933.

[2] Mallman, W. L. Effect of different brooding temperatures on pullorum disease. Vet. Med. 29:254. 1934.

oculated chicks was higher among those on diet B than on diet A, but the greatest difference was found between the inoculated chicks on diets A and B. In the White Leghorns the survival decreased from 77.8 percent on diet A to 45.8 percent on diet B, whereas in the Rhode Island Reds the survival on diets A and B were 19.2 and 7.1 percent, respectively. The weights of surviving

TABLE 1.—*Survival of chicks on diets B and A*

Diet B, laying mash

Hatch No.	Inoculated chicks		Noninoculated chicks	
	Total	Survival	Total	Survival
	Number	*Percent*	*Number*	*Percent*
1	26	15.3	28	21.4
2	37	27.0	40	82.5
3	29	13.7	28	78.5
4	23	34.7	24	87.5
5	17	35.2	18	77.7
6	25	32.0	25	84.0
Total or average	157	19.7	163	71.8
Diet A, chick mash				
7	25	92.0	15	100.0
8	43	86.0	22	100.0
9	30	90.0	20	100.0
10	35	68.5	37	97.3
11	39	76.9	39	94.7
12	80	77.5	80	98.7
Total or average	252	80.5	213	98.1

TABLE 2.—*Effect of diet on survival, to 21 days of age, of chicks noninoculated and inoculated*

Breed	Diet	Tests	Treatment	Chicks	Survival	Average weight of birds at—	
						10 days	21 days
		Number		*Number*	*Percent*	*Gms.*	*Gms.*
White Leghorn	A	4	None	107	99.1	64.6	118.0
	B	4	...do	167	87.4	57.6	102.0
	A	9	Inoculated	473	77.8	57.8	101.0
	B	9	...do	513	45.8	51.7	88.8
Rhode Island Red	A	3	None	74	93.2	64.8	119.4
	B	3	...do	74	75.7	59.1	103.3
	A	8	Inoculated	308	19.2	52.6	89.0
	B	8	...do	308	7.1	52.1	82.6

chicks at 10 and 21 days of age were greater for those on diet A.

Diet B had 20 percent of alfalfa hay meal, which was absent from diet A. Diet A had 5 percent of soybean oil meal which was not in diet B. The other ingredients were the same in kind but differed in proportions. Composition of these diets and others used in the tests is given in table 3. Both diets A and B had been ground to pass through the same sieve. Screen tests were also made of the two diets. The chick mash (diet A) had slightly more coarse material than did the laying mash (diet B); consequently, the size of particles was not responsible (table 4). Grit added to the mash had no appreciable effect.

Chemical analyses of the two diets showed a significant difference in the amount of crude fiber, diet B having more than twice as much as diet A, as shown by table 5, but we have no corroborative evidence that the difference in crude fiber is the cause of differences in mortality.

Size of the alfalfa particles has no relation to mortality. Various sizes were used, the smallest having passed through a one-half millimeter screen, without differences in results. However, when the alfalfa hay meal was omitted (diet C) the results were improved. The survivals of

TABLE 3.—*Composition of diets (in parts)*

Ingredient	Composition of diets indicated				
	A	B	C	D	E
Corn, ground	49	30	30	30	39
Wheat bran	15	10	10	10	.....
Wheat middlings	15	20	20	20	15
Alfalfa hay meal	.....	20	.....	.....	10
Alfalfa leaf meal	.....	.....	.....	20	.....
Meat scrap	10	15	15	15	10
Dried milk	5	5	5	5	5
Soybean oil meal	5	.....	.....	.....	5
Oats	.....	.....	.....	.....	15
Wood fiber	.....	.....	.....	.....	.....
Salt	1	1	1	1	1

TABLE 4.—*Screen tests for fineness of diets A and B*

Meshes per square inch	Proportion retained by screens in—	
	Diet A	Diet B
	Percent	*Percent*
8	2.9	1.3
14	15.1	12.2
28	25.5	23.5
48	18.5	22.7
100	28.9	30.0
100+	9.1	10.3

inoculated chicks on diets B and C were 21.8 and 46.2 percent, respectively. The weights of surviving chicks on diet C at 10 and 21 days of age were greater than those on diet B (table 6).

Diet H was the same as diet B except that the former contained ashed alfalfa hay meal instead of the meal itself. Survival of inoculated chicks on diet H was a little more than twice that on diet B. On diet C, which is the same as diet B except that the alfalfa hay meal was omitted, the survival was practically the same as on diet H, which contained alfalfa ash in place of the hay meal (table 6).

Diet D contained dehydrated alfalfa leaf meal in place of alfalfa hay meal, but the quantities of other ingredients were the same in both. In general, survival was higher and weights of chicks greater with diet D than with diet B (table 7).

Another test was conducted with noninoculated chicks on diets A, B, D, and E. The main differences among these diets were as follows: Diet A contained no alfalfa hay meal; diet B, 20 percent of alfalfa hay meal; diet D, 20 percent of dehydrated alfalfa leaf meal; and diet E, 10 percent of alfalfa hay meal and 15 percent of ground oats.

TABLE 5.—*Chemical composition of diets*[1]

Materials	Composition of diets indicated			
	A	B	D	E
	Percent	*Percent*	*Percent*	*Percent*
Dry substance	89.94	91.40	92.45	90.23
Ether extract	4.06	3.88	4.36	4.60
Crude protein	18.25	19.19	20.25	15.38
Ash	6.81	8.44	9.70	5.37
Crude fiber	3.98	9.71	5.64	6.25
Total nitrogen	2.92	3.07	3.24	2.46
N-free extract	56.84	50.18	52.50	58.63
Calcium	1.10	1.65	1.82	0.68
Phosphorus	1.04	1.63	1.16	.61

[1] Diet C not analyzed.

TABLE 6.—*Survival and weights of inoculated chicks on diets B, C, and H*

Diet	Chicks	Survival	Average weight at—	
			10 days	21 days
	Number	*Percent*	*Grams*	*Grams*
B	78	21.8	50.3	84.9
C	78	46.2	57.0	97.6
H	77	44.2	56.1	90.8

TABLE 7.—*Survivals and weights of chicks on diets B and D*

Breed	Diet	Treatment	Chicks	Survival	Average weight at—	
					10 days	21 days
			Number	*Percent*	*Grams*	*Grams*
White Leghorn	B	None	42	92.9	54.8	94.2
	D	...do	42	85.7	58.5	111.8
	B	Inoculated	145	32.4	50.9	89.2
	D	...do	144	46.5	56.4	98.7
Rhode Island Red	B	None	53	73.6	58.0	98.6
	D	...do	53	92.4	56.6	103.7
	B	Inoculated	41	0	......	......
	D	...do	41	0	......	......

Diet A gave the best results both in respect to survival and weight of chicks, diet B gave the poorest results, diet E was second best in respect to survival, and Diet D was second best in respect to weight at 21 days of age (table 8).

A very interesting observation was the occurrence of diarrhea among these four lots though the chicks had not been inoculated. The percentages of chicks with diarrhea on diets A, E, D, and B were 0, 15, 30, and 46, respectively, as judged by visible symptoms. On diet A without alfalfa no diarrhea occurred, whereas on diet B with 20 percent of alfalfa hay meal there was the greatest occurrence. On diet D with 20 percent of alfalfa leaf meal, more diarrhea appeared than on diet E with 10 percent of alfalfa hay meal. But chicks on both diets D and E were less affected than were those on diet B.

TABLE 8.—*Growth and survival of noninoculated chicks on diets A, B, D, and E*

Breed	Diet	Chicks	Survival	Average weight at—	
				10 days	21 days
		Number	*Percent*	*Grams*	*Grams*
White Leghorn	A	21	100.0	60.0	129.0
	B	21	85.7	50.1	95.5
	D	21	85.7	53.0	114.7
	E	21	95.2	57.5	108.8
Rhode Island Red	A	33	97.0	57.7	124.7
	B	33	72.7	44.9	93.3
	D	33	85.7	53.0	114.7
	E	33	93.9	53.5	107.6

TABLE 9.—*Survival and growth of inoculated chicks on diets A, B, and E*

Breed	Diet	Chicks	Survival	Average weight at—	
				10 days	21 days
		Number	*Percent*	*Grams*	*Grams*
White Leghorn	A	104	70.2	61.0	104.8
	B	104	40.4	52.6	86.7
	E	104	59.6	58.3	99.3
Rhode Island Red	A	93	7.5	52.9	87.2
	B	93	6.5	55.1	79.0
	E	93	6.5	49.6	76.8

When inoculated White Leghorn chicks were fed the three diets A, B, and E, the survivals in the same order were 70.2, 40.4, and 59.6 percent. The weights at 21 days, also in the same order, were 104.8, 86.7, and 99.3 grams. The survivals among the three lots of Rhode Island Reds were so low that comparisons cannot be made (table 9).

The average quantities of feed eaten per day per chick on diets A, B, D, and E were 11.7, 9.0, 11.4, and 8.3 grams, respectively. These differences in feed intake cannot account for the differences in weight among the different lots.

The various differences reported in this paper suggest that the alfalfa or something associated with it is responsible for the greater mortality and lesser weight of chicks on diets in which alfalfa is an ingredient.

SUMMARY

The effect of the environment on the expression of genes is an important phase of genetic studies. In general, the so-called physiological characters, such as egg yield and resistance to disease, are influenced to a much greater extent by the environment than is such a character as color. It is obvious, however, that all hereditary characters are the result of the interaction of both environment and genes.

In our tests for resistance to pullorum disease, laying mash was used during one period instead of the usual chick mash. Abnormally high mortality was observed among the controls, which had not been inoculated. Evidence that they were accidentally infected by *Salmonella pullorum* could not be found.

When chick mash was substituted for the laying mash the high mortality disappeared. Carefully controlled tests with both laying and chick mashes were made, and much higher mortality occurred among both inoculated and noninoculated lots on laying mash than occurred in corresponding lots on chick mash. The average weight of the chicks on chick mash was significantly greater than that of the birds on laying mash, at both 10 and 21 days of age.

The laying mash contained 20 percent of alfalfa hay meal and the chick mash none. The chick mash contained 5 percent of soybean oil meal and the laying mash none. The other ingredients were the same but in different proportions.

A diet with no alfalfa hay meal gave much better results than did the one containing alfalfa hay meal. When alfalfa leaf meal was substituted for alfalfa hay meal, better results were obtained but not so good as with the chick mash without alfalfa.

The greater mortality and lesser weights of chicks on diets in which alfalfa is an ingredient suggest that alfalfa or something associated with it is the cause of the differences found.

PULLET MORTALITY AND ITS ECONOMIC SIGNIFICANCE

By S. Bird, *Agricultural Scientist, Poultry Division, Central Experimental Farm, Ottawa, Canada*

In the course of an investigation of the economics of poultry keeping in Canada, it became apparent that pullet mortality may frequently involve such great losses in egg production and capital investment in stock as to threaten seriously the possibility of a profitable balance on the year's operations. The present study endeavors to trace the etiology of pullet mortality and to estimate the losses attributable to this cause.

A survey of the literature—Harris (1926a, 1926b), von Eichel and Krüger (1933), Lippincott and Card (1934), Jull (1934), Weaver and Bird (1934), Munro (1936), and Ferguson (1938)—provides a preponderance of evidence that birds which die during their pullet laying year are poorer layers during their production period than those which survive. Furthermore, in the present paper it is proposed to show that the morbid condition existing in a flock affects not only the birds that die but also the survivors, and this to such an extent that the level of yearly production in surviving birds is in definite inverse proportion to the level of mortality existing in the flock as a whole.

A covariance analysis of the relationship between the yearly production of surviving birds and the percentage of mortality occurring in the

Table 1.—*Covariance analysis of relationship between yearly egg production of surviving birds and percentage of mortality in progeny from 132 sires on 17 Dominion experimental farms in 1935-36*

Source of variability	Degrees of freedom	Sum of squares— For egg production	Sum of squares— For percentage of mortality	Sum of products for egg production and percentage of mortality	r (coefficient of correlation)	b (coefficient of regression)
Between locations	16	41,082	3,450	−6,832	[1]−0.574	−0.1663
Within locations	115	32,544	8,268	−2,519	− .154	....
Total	131	73,626	11,718	−9,351	− .318	....

[1] The 1-percent significant point is at 0.590; the 5-percent point, at 0.468.

Table 2.—*Analysis of variance of yearly egg production of surviving birds and percentage of mortality in progeny from 132 sires on 17 Dominion experimental farms in 1935-36*

Source of variability	Degrees of freedom	Mean square for— Egg production	Mean square for— Percentage of mortality	F value Egg production	F value Percentage of mortality
Between locations	16	2,567.6	215.6	9.1	3.0
Within locations	115	283.0	71.9	......	......
Total	131	562.0	89.5	......	......

progeny from 132 sires on 17 Dominion experimental farms during the year 1935–36 is presented in table 1. The analysis of variance is presented in table 2.

These analyses show that there was a highly significant difference in yearly production from surviving birds as well as in flock mortality among the 17 locations. Furthermore, the values for production and mortality were significantly correlated and the correlation was negative. Obviously, the correlation must be measured as between locations, as the influence of environment on production is the pertinent consideration. The correlation within locations with environment held constant would measure the influence of genetics only, which, under the present state of

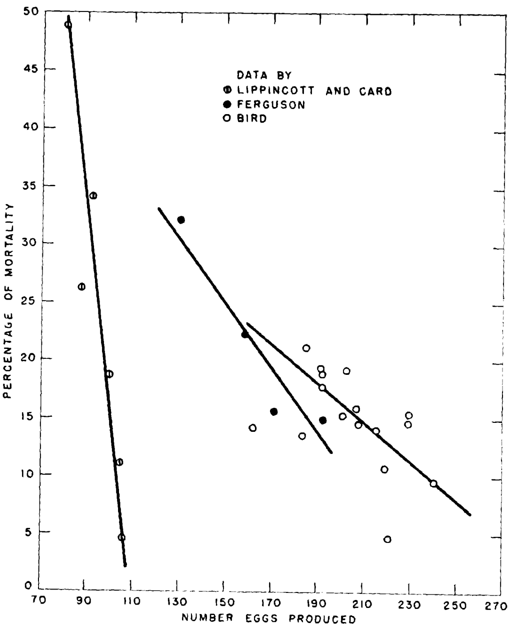

FIGURE 1.—Regression-line characteristic of analysis shown in table 1, and estimates of regressions for data of Ferguson (1938) and of Lippincott and Card (1934).

selection, is not likely to be a very potent factor. The analysis shows that the condition of morbidity in a flock is the common factor which to a certain extent will determine the percentage of mortality as well as the productive ability characteristic of that flock.

When it is considered that morbidity is the ultimate expression of feeding and other management practices, parasitic infestation, and disease infections superimposed on genetic constitution, it is logical that the mortality in a flock and the yearly production in its surviving females should be inversely correlated.

In figure 1 is shown the regression-line characteristic of the analysis shown in table 1, together with estimates of the regressions for the data of Ferguson (1938) and of Lippincott and Card (1934). The particulars for these three regressions are presented in table 3.

The "maximum attainable egg production" signifies the production values at which extensions of the three regression lines would strike the zero mortality ordinate. In such an improbable state in which all progeny flocks in the same location had no mortality, environmental conditions would probably have to be at the absolute optimum and yearly production therefore determined mainly by genetic constitution.

TABLE 3.—*Comparison of mortality and egg-production data obtained from sources indicated*

Source of data	Increase in percentage of mortality for each decrease of 10 eggs in production of surviving birds	Mean egg production	Mean mortality	Maximum attainable egg production
	Percent	*Number*	*Percent*	*Number*
Lippincott and Card	17.680	94.8	24.0	108
Ferguson	2.917	162.8	21.2	240
Bird	1.663	206.3	15.4	300

TABLE 4.—*Comparison of pullet mortality in old and new houses*

Contest	Age of old houses when abandoned	Pullet mortality— Average last 3 years in old houses	Average first 3 years in new houses
	Years	*Percent*	*Percent*
Canadian	11	[1]23.7	[1]32.3
Nova Scotia	11	[1]20.1	[1]21.2
New Brunswick	11	13.3	[1]20.4
Quebec	3	11.8	16.2
Manitoba	8	13.8	9.5
Saskatchewan	7	8.3	14.7
Alberta	7	8.5	[1]29.9
Average	....	14.2	20.6

[1] Infectious diseases or intestinal parasitism present.

On these premises the three populations must be assumed to have been genetically different. The three regressions indicate that resistance to the detrimental influences of the environmental complex rapidly becomes weaker as the genotype becomes poorer. The conception thus unfolded of the high-producing genotype as the rugged type which is highly resistant to environmental hazards and the low-producing genotype as the one that will easily succumb to an adverse environment is probably somewhat at variance with general opinion. The evidence seems to be so conclusive, however, that the best possible safeguard against mortality is to select intensively for the highest possible mean production and when the strain has been established to subject the birds to a minimum of morbid conditions. How this is to be accomplished in detail is at present not entirely clear. However, some information may be had by analyzing past records for the egg-laying contests conducted on 14 Dominion experimental farms. These records cover the years from 1919-20 to 1933-34 and are particularly valuable because of the fact that culling was not practiced throughout these 15 years. Most of these contests began in colony houses, each accommodating two separated pens. In seven instances entirely new houses were provided from 3 to 11 years after the inauguration of the contests. These new houses were of the continuous type with all separate pens housed under one roof. Both old and new houses were well-built, double-wall structures with fronts consisting of one-third wood, one-third cotton, and one-third glass. Dropping boards and nests were placed at the rear. In table 4 are compared the average death rates for the last 3 years in the old quarters and the first 3 years in the new houses.

TABLE 5.—*Mean mortality of flocks in egg-laying contests conducted on 14 Dominion experimental farms*

Year of contest	Contests	Mean mortality
	Number	*Percent*
1919-20	7	9.16
1920-21	10	10.54
1921-22	10	13.60
1922-23	11	11.61
1923-24	12	14.17
1924-25	13	10.00
1925-26	13	13.43
1926-27	13	15.88
1927-28	13	21.15
1928-29	13	18.85
1929-30	13	19.33
1930-31	14	26.82
1931-32	14	25.39
1932-33	14	22.95
1933-34	13	21.71

Evidently new housing was not efficient in restricting mortality.

The mean mortality for all contests through the years and a variance analysis of the same are presented in tables 5 and 6.

The mean mortality for the first 8 years is 12.3 percent. These are followed by 3 years with a mean of 19.8 percent, and these again by the last 4 years with a mean mortality of 24.2 percent. The differences among these three group means were found to be significant and together produce the highly significant F value of the variance analysis. The total number of deaths occurring in the contests throughout the 15 years was 10,196, but actual autopsy records are available on only a minority of these specimens. However, the first increase in the average percentage of mortality was probably caused by a general spread through the country of the newer forms of coccidiosis, and the second significant increase in death rate was probably due to a general spread of laryngotracheitis. This appears to be reasonably good evidence for the statement that the major source of increased mortality is the contact of disease-free birds with well-established morbid conditions.

Further evidence of the soundness of this statement was obtained when on the Central Experimental Farm all old stock was disposed of during the summer of 1936, thereby effectively breaking contact between the older birds and the young stock coming in from range. In the years previous to this event the percentage of mortality had been 54.3 in 1932-33, 43.5 in 1933-34, 24.8 in 1934-35, 30.1 in 1935-36. In the year following the disposal of old stock, 1936-37, mortality dropped to 12.8 percent. Therefore, such events as contests, exhibitions, transfer of stock from one location to the next, and contact between one generation and another in the same location all establish conditions favorable to the transfer of infections and infestations and thus create the morbid conditions which may act to the detriment of productive abilities.

In attempting to apply the findings presented to practical poultry husbandry in Canada, reliance must be placed on the more or less accurate estimates of total fowl population and mean annual egg production. The latter is nearly 100,

TABLE 6.—*Analysis of variance of percentage of mortality of flocks in egg-laying contests conducted on 14 Dominion experimental farms*

Source of variability	Degrees of freedom	Sum of squares	Mean square	F value
Between contest years	14	5,756.98	411.21	8.66
Within contest years	168	7,977.88	47.49	....
Total	182	13,734.86	75.47	....

and the data by Lippincott and Card as presented in figure 1 and table 3 may therefore serve our present purpose. The maximum attainable production for this regression was found to be 108 eggs, the mean production 95 eggs, and the mean mortality 24 percent. Munro (1936) showed that the birds which die are affected so much more severely by the prevalent morbid condition that their production is, on the average, 6.5 percent less than that of the survivors. Weaver (1930) has shown that production and mortality attain their modal values simultaneously in the spring. If we assume that both of these values are distributed normally about their modes, we may estimate the loss in egg production for each bird that began the year by solving the following equation:

$$x = a - (b + c) \qquad (1)$$

where x is the loss in production per bird that began the year, a is the maximum attainable production under optimum conditions, b the mean full-year production for the percentage of surviving birds, and c the mean one-half year production for the percentage of the birds that die.

Substituting the data enumerated in equation (1), this becomes

$$x = 108 - \frac{(95 \times 76) + \left(\dfrac{\dfrac{95 \times 93.5}{100} \times 24}{2}\right)}{100} \quad (2)$$

and solving equation (2) we obtain

$$x = 25.4.$$

This result signifies that of the estimated maximum attainable production for Canadian chickens, mortality results in a loss of 25.4 eggs per bird that began the year. Applying this figure to the 24.5 million hens listed for Canada in table 2 of the "Agricultural Statistics" (1937), we find a total loss, for the year, of approximately 52 million dozen eggs. At an average price of 27 cents per dozen, the total monetary loss due to mortality is estimated at about 14 million dollars. This loss is so important that it should act as a powerful incentive to select for mortality resistance which, as shown, implies selection for high production. Subsequently care should be exercised to guard against the introduction of morbid conditions to such strains.

SUMMARY

Mortality in a flock is negatively correlated to the annual egg production from its surviving birds. The morbid condition existing in a flock therefore affects not only the birds that eventually succumb but also those that survive. Morbidity, therefore, acts as a general depressor of efficiency.

The regression of mortality on production increases very considerably as the genotype becomes poorer. Strains of birds that are genetically high egg producers therefore constitute the more rugged and resistant type.

Control of mortality, therefore, may be accomplished most effectively through selection for high egg-producing ability. Subsequently, such strains should be guarded against contact with established conditions of morbidity. Transfer of stock from one location to another and contact between young and older generations probably constitute the gravest dangers in this respect.

It is estimated that the total annual loss in egg production throughout Canada which is directly ascribable to morbidity with its attendant mortality amounts to approximately 52 million dozen eggs. The monetary value of these eggs is about 14 million dollars.

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THE ORIGIN OF THE EUROPEAN "DUNGHILLCOCK"

By Ir. J. B. Vries, *The National Institute for Poultry-Breeding, Beekbergen, Netherlands*

In 1929 Prof. Serebrovsky (Moscow) wrote that the history of the domestication and the distribution of fowl has been studied more than that of any other animal. It was undoubtedly the enthusiasm for the brilliant investigation which he and his students made into the geographical differentiation of the genes within the races of the Russian fowl that caused him to make this statement. For, when in 1936 I began my investigation of the origin of the Dutch races of fowl, and was compelled to consult the available foreign data, it soon appeared to me that there is probably no domestic animal about whose geographical forms we know so little as our domestic fowl. Here more than with any other animal there is the danger, pointed out by Heck and Hilzheimer (1928), of the original breeds being displaced by inbred general-purpose breeds. This not only will be a great loss to the science of poultry breeding, but also various investigators, notably Hilzheimer (1928) and Serebrovsky (1929), draw attention to the importance of a thorough knowledge of poultry and domestic animals in general for various zoological, anthropological, and ethnographical problems. Especially during the last 20 to 40 years the original poultry races have rapidly deteriorated and have been superseded by modern general-purpose breeds. With this there have come gaps, which cannot be filled, in our knowledge of types of poultry.

What is known about poultry in various countries relates only to some races, i.e., definite combinations of factors which have been selected from the majority and which have been bred to a type which appeals to the breeder. Obviously these facts do not give any information about poultry as originally found in those districts. In many cases it is already too late to obtain reliable data on this point.

Our knowledge of poultry in some places is still less. It is generally known that in Africa large numbers of poultry are found kept by the different native tribes. In modern poultry literature, photographs of fowl from central Africa are entirely lacking. The only thing I could find was a short description of fowl of the Bantu negroes.

If we turn to Europe, we find that there are no data about fowl in Greece, Bulgaria, Turkey, Albania, not even in Rumania, and information from Hungary, Yugoslavia, and Poland is fragmentary. Similar information in Switzerland also, as well as in Ireland, as far as I have been able to determine, is entirely lacking. Nor do we have any information from Norway, Sweden, Finland, and the Baltic States. From France, Germany, Italy, Spain, and Great Britain we know various races. In these countries the old barnyard fowl has not been minutely described. It is true Düringen (1923) mentions the old German barnyard fowl but does not carefully describe the various color types. Probably only a few of these birds are still left in these countries. An investigation of this matter will undoubtedly be of considerable importance to the science of poultry. In western Europe probably the Netherlands, and of this country the Province of Friesland, is the only territory where they hold their own with some fanciers and on some farms.

Of all the poultry experts there has been only one who realized, more than 50 years ago, that a description only of a definite race and coloration was not sufficient, but that all animals in a certain district had to be thoroughly studied. In his studies of poultry which he began at Meppel as early as 1882, at the age of 12, our countryman, Mr. R. Houwink Hzn, followed the principle which not until 1920-30 was applied by Serebrovsky in a modern form. He made a careful study of fowl, especially in the Dutch province of Drente in the years in which fowl from abroad had not yet been imported. These data are unique. Thus Houwink was able to distinguish 21 types of color, which for the greater part could be traced from the partridge color (fig. 1). So he saw the partridge color with "pel" (autosomal barring) as the primary type. In Friesland the primary type is "pel." There the partridge color is lacking. As a result of various journeys, Houwink was able to show that in the Netherlands and in Belgium, Germany, and Switzerland the same barnyard fowl was found[1].

What is the origin of this European barnyard fowl, of which the primary type is represented in figure 1?

Hertwig concluded in 1936 in her summary of the data about the origin of domestic fowl

> that all historical data point to India and Southern China as being the places of origin of domestic fowl and in South-East Asia the wild species are still living from which our domestic fowl must descend.
> Gallus Bankiva, Gallus Sonnerati, Gallus Lafayette and Gallus Varius may be considered to be the ancestors of our domestic fowl.

Darwin considered the Bankiva to be the only ancestor. This belief was immediately opposed. Tegetmeier defended a separate ancestor for the Cochin Chinas. Davenport (1914) thinks that "the Jungle fowl is the foundation stock of our

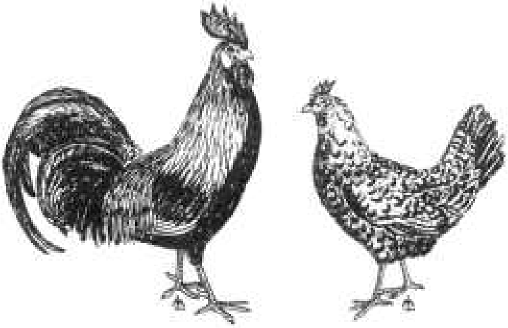

FIG. 1—Dutch barnyard fowl

nervous, flighty, egglaying races—the Leghorn, Minorca, Spanish, Andalusian, etc. . . ." By the side of these he distinguishes the group of game fowl (Malay, Aseel) with a separate ancestor.

> Representatives of the Aseel type (which had long been established in Eastern India and China) were brought to America, becoming the ancestors of the Asiatic breeds and the fine, general purpose breeds—the Plymouth Rocks, Wyandottes, Orpingtons, etc.

Ghigi, too, comes to these two groups.

Some investigators still adhere to Bankiva as being the only ancestor. It is now generally held, however, that our domestic fowl descends from the four wild species, whereas by different investigators a separate ancestor is assigned to the so-called Asiatic types. To state briefly: European poultry have been imported from Asia.

If the statement of Professor Mayer (Wageningen) "Wichtig ist das gut geleitete Experiment geschulter Forscher, wichtiger aber die richtige logische Fragestellung" holds true anywhere in the science of poultry, it must certainly do so for the problem of descent. Different crossing experiments between domestic and wild fowl have

[1] Further details will be published in "De geschiedenis van Nederlandsche Hoenderrassen" by R. Houwink Hzn and Ir. J. B. Vries.

already been made. What are the conclusions of these experiments in this respect? Only negative. If the birds are not fertile inter se, descent is practically out of the question. If they are fertile inter se, nothing has yet been proved. It is true that *Sus scrofa* (European wild pig) and *Sus vittatus* (Indian wild pig) are fertile inter se, and yet nobody will think a moment of seeing an imported *vittatus* in *Sus scrofa*. The possibility of crossing demonstrates nothing in the investigation of the origin. It only points to the same species ("*Art*") so that the forms suitable for crossing are to be considered as "geographical races" of one species. (Rensch, Remane, etc.). Also the occurrence of "some identical genes" in the "wild species and the domestic fowl" (Hertwig) points in the same direction.

In studying the origin of our poultry, too little attention has been paid to the existence of fowl during the period of domestication as well as in prehistoric times.

An investigation of the remnants of animals of former times involves many difficulties. Thus, for instance, it is very difficult to date them. During former investigations the remnants from the various layers for the most part were not kept separate. At that time small bones were overlooked, because there was an interest only in large bones. Sometimes the layers cannot be very well distinguished, or the caves were continuously inhabited for a long time, so that the remnants may belong to different periods.

Even chronology is much less fixed than is often assumed, according to Kühn (1938) and Penck (1939).

If one compares Asia with Europe as far as the remnants are concerned, it appears that no diluvial *Gallus* remnants are found, as pointed out by Lambrecht (1932). On the other hand, Boule (1927) says, in discussing a *Gallus* remnant from southern France, "Certains documents du même genre, en provenance de diverses localités françaises, me permettent de soupçonner l'existence de vrais *Gallus* dans nos pays à l'époque pleistocène."

In fact, we see that in literature *Gallus* remnants are mentioned as of the glacial period in Belgium, Germany, Hungary, France, Italy, and Switzerland. Also, *Gallus* remnants are known in the forest age following the glacial period. For that time Woldrich distinguishes four forms in Bohemia, of which, according to him, the largest form and the *Gallus domesticus* are almost identical. Also in the caves of the German Ostmark *Gallus* remnants of that period have been found. In France a *Gallus* remnant is known to us from the Magdalenien of Feyat (Dordogne).

Piette represents in his "L'art pendent l'age du Renne" a piece of worked reindeer horn from the cave of Maz D'Azil, which he thought was a sphinx (fig. 2, *A*). Breuil reconstructed it into a "bâton de commandement" with a capercaillie (*Tetrao urogallus*) on it (fig. 2, *B*). As to this reconstruction, it seems to me more likely that in this case we deal with a *Gallus* cock, especially with regard to the tail (fig. 2, *C*). If so, this would be the earliest representation of a cock known.

Fowl remnants of the neolithic age have practically not been preserved. The remnants from the caves of Ocjow (Poland), Légeny (Hungary), and the pile dwellings of the Roseninsel (Bavarian Alps) may belong to that time.

In Portugal we find a representation of a cock of this period on a dolmen stone of Traz-os-Montes. As poultry were holy birds in western Europe and not birds for production even as late as Roman times, it should not be surprising that the number of remnants is so small.

FIG. 2—*A*, Piece of worked reindeer horn of the cave of Maz d'Azil; after Piette. *B*, Reconstruction by Breuil. *C*, Reconstruction as a Gallus Cock.

Several fowl remnants have been found in the Terramara of Italy, which were inhabited from the transition of the Neolithic-Bronze period till 1100 B.C., before or, at the latest, simultaneously with the Aryan invasion of India.

Also in Austria a fowl remnant of the Bronze period has been found. Among the rock drawings from Sweden of the later Bronze period a cock also appears.

In Greece the cock can be shown with certainty only after the Dorian invasion. These people came, like the Terramara population, from Central Europe (Reche).

Let us now turn to Asia and Africa. In ancient Sumer the cock was known under the name of Tar-Hu. In Egypt the oldest find is predynastic. Different investigators do not consider the bird in question to be a cock. After this the first positive finding is a drawing between 1400 and

1100 B.C. The first appearance of the cock in China is not certain.

In India the earliest, and as far as I know the only, fowl remnants come from the excavations of Mohenjo-Daro on the Indus (about 3000 B.C.). According to investigators, these remnants indicate a much larger type than the present domestic fowl in those regions. A few seals show stylized fowl. Information about fowl remnants from the Vedas cannot be previous to 1200 B.C. in India, because as early as that the Aryans invaded the country. In view of these data, a probable taming of one or more poultry forms in Europe must not be excluded, a point which was brought forward in 1864 by Marschall in a discussion of a work by Alphonse Milne-Edwards. The evidence of a prehistoric importation from India has not yet been proved. The European findings can be compared only with the skeleton remains of Mohenjo-Daro, and according to some investigators in this culture distinctly European elements are found.

A thorough investigation of both the geographical forms of our present domestic and wild fowl and the prehistoric remnants is necessary in order to settle this problem definitely. In my opinion for the present an autochthonal origin of the European barnyard fowl is more probable than an Asiatic importation.

As to the deviating types in Europe, it does not seem improbable to me that characteristics such as a beard, crest, foot feathering, and deviating comb forms are based on a cross between the Aseel-Malay form and our barnyard fowl. The earliest Game forms in Europe occur on the coins of Carystus on Euboia (Greece), toward the end of the fourth century B.C. Later, we see them also on Roman reliefs (crested fowl are already found in ancient Rome).

In that direction also points the fact, that essential points of deviating poultry forms in Europe mostly coincide with regions where Games are found.

SUMMARY

Of the geographical distribution of our domestic fowl only little is known. The data that we have, are practically descriptions of only a few races, whereas a description of the great majority of the fowl which have not been graded up is lacking.

The first to realize the great importance of a thorough description was Houwink, who broke the ground in this field in Holland. In Russia during the past 20 years Serebrovsky described all fowl of different districts.

It is, therefore, of considerable scientific importance that every country describe what is left of barnyard fowl and save them from extinction.

It is generally assumed that the domestic fowl were tamed in Asia and descend from the four wild species now still alive.

As regards the prehistoric finds, it seems to me more likely that at least the European barnyard fowl descends from one or more European wild species which after the glacial period were still alive in the woods.

The deviating fowl types in Europe may be considered to be a cross of Indian Game forms (Aseel Malay) with the European barnyard fowl.

POULTRY REARING IN NORWAY—ORGANIZATION AND MARKETING

By LEIF SVENDSEN, *Secretary to the Norwegian Poultry Society, Oslo, Norway*

In the matter of poultry rearing, Norway cannot be compared with the great egg-exporting countries. In Norway the object is first and foremost to produce sufficient eggs and table fowl for the home market. The possible surplus production must then be exported.

NUMBER OF POULTRY

Poultry in Norway have been steadily increasing in numbers during the last few decades. The official statistics are shown in table 1.

The poultry are distributed in all sections of the country as part of the livestock kept on the farms. Poultry rearing as a separate means of livelihood is very rarely pursued and most of the the flocks are small. In 1937 the distribution was as follows:

Number of adult fowl	Percentage of flocks
1– 10	31.7
11– 25	34.3
26– 50	20.1
51–100	8.8
More than 100	5.1

The total number of flocks was 195,809, and 300 of these contained more than 500 birds each.

EGG PRODUCTION

Before the World War Norway imported eggs to the value of 200,000 to 250,000 kroner annually. The situation became worse in the postwar period, the value of the imports in 1921, for instance, being 14.3 million kroner. Since 1924 the situation has become completely reversed, thanks to the systematic work of enlightenment and to the support afforded by the State toward the advancement of poultry keeping.

Last year Norway exported 1,369,392 kg of eggs, of which 940,040 kg went to England and 429,352 kg to Germany. It is estimated that the total production of eggs in Norway is now about 28 million kg annually. As mentioned previously, the exports represent purely a surplus exportation.

ORGANIZATION OF POULTRY BREEDING

Before the year 1884 we had no organization for the promotion of poultry rearing. The formation of the Norwegian Poultry Society in that year, therefore, must be designated a turning point. The purpose of the society was to obtain more extensive and more rationally conducted poultry keeping in town and country, new and purebred pedigree birds, and to furnish designs for fowl houses, etc.

As an important feature of this work the society began the issuance of the "Tidsskrift for Fjörfeavl," a publication which is still appearing and which is the only special journal for poultry keeping in Norway. Furthermore, the organization endeavored to establish a more modern system for the marketing of eggs through cooperative societies and egg-selling pools. Control breeding stations and breeding centers for hens were established, which until 1929 were directly under the Poultry Society but were afterwards taken over by the State. The Norwegian Poultry Society comprises 17 county organizations, to which are affiliated 125 local subsections. Since 1891 the society has been in receipt of a grant from the State, and it is under the patronage of H.M. King Haakon VII.

TABLE 1.—*Numbers of different species of poultry in years indicated*

Year	Chickens	Turkeys	Ducks	Geese	Total
	Number	*Number*	*Number*	*Number*	*Number*
1890	796,563	1,516	5,446	4,840	808,365
1900	1,639,695	3,702	8,152	7,488	1,659,037
1907	1,460,359	3,151	9,031	9,898	1,482,439
1916	1,668,310	3,062	4,439	5,078	1,680,889
1929:					
Adult birds	2,963,655	6,321	10,738	9,353	2,990,067
Young birds	1,599,879	8,676	9,310	15,031	1,632,896
1938	3,919,633				

MEASURES FOR IMPROVING THE BREEDS

The systematic efforts for improvement of the breeds are based on the aforementioned control breeding stations belonging to the State. Of these, 23 are distributed in all parts of the country. The stations are directly under the control of the Department of Agriculture and are conducted by a Government consultant. The task of the stations is to furnish first-class stock to the breeding centers and to poultry keepers. At these stations the fowls are subject to individual control, so that poor layers or birds of defective external appearance can always be discarded.

As an illustration of the progress effected by the control stations and of the accomplishments in this matter by systematic breeding, table 2 is included, showing the average yearly production of eggs per fowl.

In the last year the number of eggs was slightly smaller, but the weight per egg had increased (for the first, second, and third years, respectively) from 57.6 g, 61.9 g, and 61.7 g to 57.8 g, 62.2 g, and 63.1 g. Therefore, the total weight of the eggs had increased in the last year also.

In 1935–37 the control breeding stations supplied the numbers of eggs and birds shown in table 3.

What this yearly increase of first-class stock for breeding has meant to the Norwegian poultry keepers is shown by the following egg production per hen per year, applying to the entire country:

Year	Number
1890	80
1910	95
1930	110
1938	128

TABLE 2.—*Average yearly egg production per fowl*

Year	First year of laying	Second year of laying	Third year of laying	Total
	Number	*Number*	*Number*	*Number*
1922	157	119	84	360
1925	165	136	117	418
1930	207	155	134	496
1935	221	187	157	565
1937	219	174	152	545

TABLE 3.—*Numbers of eggs and birds supplied by control breeding stations in 1935–37*

Year	Eggs for hatching	Day-old chicks	Pullets	Cocks for breeding	Total sale computed in hatching eggs
	Number	*Number*	*Number*	*Number*	*Number*
1935	100,522	113,294	11,140	1,020	375,750
1936	73,382	132,629	10,883	1,183	386,904
1937	70,824	146,740	12,885	1,664	422,500

COOPERATIVE MARKETING OF EGGS

Since the beginning of the century, cooperative marketing of eggs had been attempted in different parts of the country. This movement, however, did not make much advance until about the year 1930, when the production had greatly increased. The importation of eggs had stopped and the surplus production had to be exported. Some years earlier a number of egg-selling pools had been established, and in 1930 these became amalgamated in the Norske Eggcentraler S/L, which conducts all the exportation from the selling pools, while at the same time it deals with the cooperative marketing in the capital city, Oslo. Besides working for a rational system of marketing, the Norske Eggcentraler S/L has led the way in the efforts to improve the quality of the eggs. Moreover, the system of official price quotations for eggs has been established in three of the largest cities in Norway.

Since 1935 we have had the Export and Quotation Committee for Eggs. The chairman of this committee is appointed by the Department of Agriculture, the other members being three representatives of the Norske Eggcentraler S/L and three representatives of the wholesale egg merchants in Oslo. This committee directs the official control of egg quality.

Four State inspectors have been appointed, one for each of the four largest cities. Inspections are made not only of eggs intended for export, but also of those which are disposed of in the home market.

The producers are paid for the eggs according to quality, and deductions for undesirable eggs are made from the purchase price at the following rates: For rotten eggs, 20 öre per egg; for stale eggs, 2 öre; for eggs with blood specks, 5 öre; and for eggs with damaged shells, 2 öre. In this manner a steady improvement in quality has been attained.

As a further contribution toward improvement of quality, regulations are made respecting storage rooms, technical equipment, and methods of packing.

Altogether, large sums have been spent for the purpose of insuring good quality, not only with a view to exportation but also to attain an increased consumption in the home market.

TABLE 4.—*Exports and imports of killed poultry, 1932–38*

Exports

Year	Killed hens		Other poultry	
	Weight	Value	Weight	Value
	Kilograms	*Kroner*	*Kilograms*	*Kroner*
1932	313,149	269,811	1578	4,068
1933	307,125	283,972	120	125
1934	149,662	372,826	18	24
1935	143,193	159,623	24	45
1936	50,292	53,103	32	79
1937	116,934	129,660	50	45
1938	51,235	59,141		

Imports

Year	Killed Poultry	
	Weight	Value
	Kilograms	*Kroner*
1932	4,849	9,890
1933	7,193	12,494
1934	8,070	14,869
1935	7,878	13,977
1936	6,393	11,119
1937	17,351	29,929
1938	6,629	12,591

POULTRY FOR THE TABLE

We have as yet no organized marketing system for poultry intended for the table, but efforts in this direction are now being made. In 1935 the first modern cooperative slaughterhouse for poultry was established at Sandnes, and the egg-marketing board in Trondheim has for several years been operating on a small scale in this line. A movement is now on foot to establish a modern slaughterhouse for poultry in Oslo, which would at the same time regulate the market in the capital and furnish official price quotations for killed poultry.

According to returns issued by the Central Bureau of Statistics, Norway's exports and imports of killed poultry during the last 7 years were as shown in table 4.

OTHER SERVICES

The State Egg-Investigation Service was established in 1932 and is conducted by the State consultant for minor industries. This institution carries out various investigations, including examination of eggs sold on the home market. A large number of investigations have been pursued respecting storage of eggs and their keeping properties under different temperatures, storage conditions, etc.

The State Veterinary Institute makes, free of charge, all examinations of living and dead poultry, as well as of blood samples, submitted.

As early as in 1884 the Norwegian Poultry Society began to give instruction in poultry keeping through occasional lectures. Afterwards, the instruction was extended to comprise courses of 1 or 2 days' duration, and itinerant teachers were sent out to the larger districts. These teachers also gave lectures on poultry in the county agricultural schools. In 1915 the State Training School for Teachers to Smallholders was established, with a special teacher in poultry breeding. From that year the poultry keeping industry became more systematic. Many of the teachers trained at the school have poultry breeding as their main subject.

Later, schools for smallholders, were established, at which both theoretical and practical instruction in poultry keeping is given.

In the present year, for the first time an assistant professor in poultry-breeding was appointed at the Norwegian College of Agriculture.

PUBLICATIONS

In Norway we are now acquiring a considerable amount of literature in the field of poultry breeding.

In addition to the Norwegian Poultry Society's "Tidsskrift for Fjörfeavl," which appears every fortnight, the Skandinavisk Fjaerkraeavlerforbund (Scandinavian Poultry-breeders Union) has since 1937 been publishing a quarterly journal, "Nordisk Fjäderfätidsskrift," containing articles with summaries in English and German.

The State consultant for minor industries issues every year a report concerning, among other things, the State control breeding stations. The Training School for Teachers to Smallholders also issues an annual report and record of experiments.

A large number of booklets on poultry, eggs, etc., have been published from time to time. The largest work on poultry hitherto issued in Norway, "Norsk Fjörfebok" ("The Norwegian Poultry Book"), appeared last year, and several other textbooks on poultry rearing have been published. The Department of Agriculture and the Norwegian Poultry Society have issued a number of pamphlets and leaflets on various matters concerning poultry keeping.

SUMMARY

Poultry keeping in Norway is a part of the farmer's ordinary stock-rearing activity.

Systematic efforts are being made to improve the quality of eggs and table fowl.

Through Government grants and other measures, an effort is being made to increase the annual production of eggs per fowl and, likewise, to obtain healthy and vigorous poultry.

The improvement and extending of the cooperative marketing of eggs and table fowl are being attempted.

Practical and theoretical instruction in poultry keeping is being given at all agricultural and smallholder schools throughout the country. Last year 10 itinerant teachers were appointed by the Government. In addition to these, there are about 150 district itinerant teachers who are partly or wholly occupied in giving instruction in poultry rearing.

STUDIES OF INDIVIDUAL LAYERS

By D. C. KENNARD, *Associate, and* V. D. CHAMBERLIN, *Assistant, Department of Animal Industry, Ohio Agricultural Experiment Station, Wooster, Ohio, U. S. A.*

The primary source of poultry information is the flock rather than the individual. Likewise, experimental data, aside from trap-nest and pedigree records, deal chiefly with flock averages. Flock averages, at their best, present only an obscured representation of the individuals composing the flock. In some instances they may give rise to misinterpretations and erroneous conclusions.

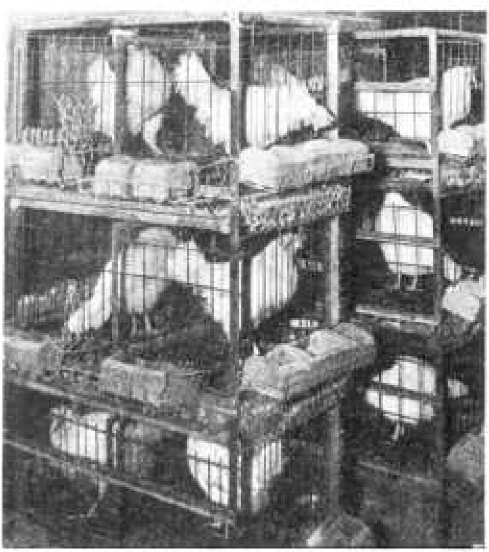

FIGURE 1.—A portion of the laboratory for studies of individual layers at the Ohio Agricultural Experiment Station at Wooster.

Because the study of individuals, although very limited by the great amount of time and expense involved, provides information not otherwise available and individual data that are a valuable aid in the more intelligent interpretation and understanding of flock averages, the Ohio Agricultural Experiment Station at Wooster began studies of individual layers on October 23, 1933.

The project included 12 Single-Comb White Leghorn layers housed in metal battery cages 12 by 16 inches in size and placed in two 3-tier units, each of which accommodated six layers as shown in figure 1. The 12 original birds were ready-to-lay pullets. When a bird died it was replaced by a ready-to-lay pullet or a young pullet layer, the replacement birds, therefore, being 5 to 9 months of age. After 5 years, none of the originals remained. Of the 52 birds placed on test, 32 lived less than a year, 10 lived 1 to 2 years, 6 lived 2 to 3 years, 3 lived 3 to 4 years, 1 lived 4 to 5 years. Six laid more than 200 eggs in a single year; the highest number laid was 262. Four laid a total of 400 eggs or more each; the highest number was 579. Needless to say, the high rate of first-year mortality was due to the condition of the pullets before they entered the test rather than to the conditions to which they were subjected afterward. The weights of whole grains, mash, grit, oystershells, and other ingredients of the ration were recorded for each week, as were the body weights of each bird. During the first 18 months the daily water intake was recorded.

This paper presents only a few phases of the studies of individual layers carried on at Wooster. There is little attempt to present definite interpretations of the data to follow. The primary object is to present the data for the reader's personal interpretations in accordance with his viewpoints and experiences.

VARIATION OF INDIVIDUALS DURING COMPARABLE EGG PRODUCTION

In table 1 are data from seven individual layers with a high rate of egg production during a period of 36 weeks. Since the rates of egg production are comparable, the variations in feed and water intake can be attributed largely to differences in individuals. The three layers receiving all-mash rations permit a close comparison of feed intakes. If the differences between weights of eggs produced and body weights of layers 1 and 3 are taken into consideration, their total feed requirements were very similar. Likewise, the greater feed intake of layer 2 can be attributed largely to her greater weight of eggs and body weight.

Layers 4, 5, 6, and 7 had a free choice of whole corn, wheat, oats, and a mash. A wide variation is noted in the proportion of feed ingredients between the all-mash and the grain-and-mash rations. This difference tends to complicate any comparison to be made of the individual feed requirements for a given weight of egg production. Layers 4 and 5 were closely comparable as to egg production and feed intake, and both were heavy consumers of whole oats, whereas their percentage of protein intake was 3 to 4 percent below that of layers 6 and 7, which consumed more high-protein mash and less oats. May the difference in oats consumption have affected the protein intake? No explanation is offered for the higher total feed intake of layer 6, but it should be noted that her 36-week period of egg production was during her second year in the test; whereas the records of the other layers were taken during their first year. Of the seven layers No. 6 (figure 2) was the outstanding bird both from the standpoint of longevity and egg production. She was 4 years

TABLE 1.—*Comparison of individual Single-Comb White Leghorn layers during 36 weeks of high egg production*

Item	Bird No.—						
	1, fed all-mash	2, fed all-mash	3, fed all-mash	4, fed grain and laying mash	5, fed grain and mash concentrate[1]	6, fed grain and mash concentrate[1]	7, fed grain and mash concentrate[1]
Number of eggs	177	183	173	173	170	165	163
Egg production, percent	70.2	72.6	68.6	71.0	67.5	65.5	64.7
Weight of eggs, pounds	20.84	24.07	20.37	21.57	20.42	21.28	21.21
Whole grain fed, percent:[2]							
Corn	....	....	....	19.8	10.2	24.2	5.7
Wheat	....	....	....	[3]11.2	35.4	34.1	59.4
Oats	....	....	....	25.6	30.4	11.8	6.1
Total	....	....	....	56.6	76.0	70.1	71.2
Mash fed, percent:[2]							
Meat scrap	10	10	10	6.5	10.8	15.5	15.6
Dried skim milk	3	3	3	2.2	3.6	5.2	5.2
Wheat bran	10	10	10	4.3	3.6	5.2	5.2
Wheat middlings	20	20	20	8.7	....	....	....
Corn, ground	30	30	30	10.8	....	....	....
Oats, ground	20	20	20	8.7	....	....	....
Alfalfa meal	5	5	5	2.2	....	....	....
Total	98	98	98	43.4	18.0	25.9	26.0
Alfalfa hay fed[4]	2	2	2	....	6.0	4.0	2.8
Protein fed, percent[2]	17.38	17.38	17.38	14.94	15.31	18.94	19.46
Salt fed, percent	1	1	1	.43	.10	.17	.14
Oystershell fed:							
During experiment, pounds	2.69	1.97	3.06	2.35	4.95	2.73	3.05
Per year, pounds	3.88	2.84	4.42	3.05	7.15	3.94	4.40
Percentage of total feed	5.32	3.03	6.26	4.10	8.61	4.18	5.73
Granite grit fed:							
During experiment, pounds	4.87	.75	.06	.09	4.34	.93	1.09
Per year, pounds	7.03	1.08	.08	.13	6.26	1.34	1.57
Percentage of total feed	9.63	1.15	.12	.15	7.55	1.42	2.05
Feed intake during experiment, pounds[5]	50.55	64.82	48.83	57.00	57.46	65.23	53.14
Yearly feed intake, pounds	73.01	93.63	70.53	82.33	82.99	94.22	76.75
Feed per pound of eggs, pounds	2.42	2.69	2.39	2.64	2.81	3.16	2.50
Water times feed	2.65	1.91	(6)	(6)	1.85	2.26	2.22
Body weight:							
Initial, pounds	3.79	4.42	3.77	3.65	3.79	3.59	3.92
Final, pounds	4.45	5.11	4.10	3.79	4.56	4.21	4.08
Weekly average, pounds	4.16	4.79	3.88	3.68	4.29	4.12	4.02

[1] Mash concentrate composed of meat scrap (50-55 percent protein) 60 percent, dried skim milk 20, wheat bran 20, salt 1.

[2] Percentage of total feed exclusive of oystershell, granite grit, salt, cod-liver oil, and chopped alfalfa hay.

[3] Wheat omitted after 18 weeks. First 18 weeks, percentage of whole-grain consumption was corn 13.08, wheat 22.51, oats 21.25. After omission of wheat, percentage of consumption was whole corn 26.22 and whole oats 29.95.

[4] Chopped and fed ad libitum.

[5] Cod-liver oil also fed at the rate of 1 percent of total feed.

[6] Not recorded.

and 3 months old when photographed July 22, 1938 and had laid 580 eggs. She was the only one of the seven birds living in January 1939 and was laying occasionally. The longevity in weeks and total eggs laid respectively by the others were as follows: Layer 1, 68 and 246; layer 2, 43 and 183; layer 3, 52 and 243; layer 4, 48 and 215; layer 5, 98 and 285; layer 7, 206 and 360.

Although the individual consumption of oystershells was variable, there was a much greater difference in the consumption of granite grit, which varied from practically 0 to 9.63 percent of total feed intake. There was no indication that the grit intake was affected by all-mash or whole-grain-and-mash rations. In fact, a study of the results obtained from birds 3 and 4 might raise the question as to whether or not the hard grit was essential.

The average weekly body weight, as well as the final body weight, of these layers exceeded their initial weight after the 36-week high egg production. This result was expected, in view of the data presented in table 3.

COMPARISON OF INDIVIDUAL LAYERS DURING HIGH, MEDIUM, LOW, AND NO EGG PRODUCTION

The previous discussion has dealt with a comparison of individual layers with a high egg production for a given period. Table 2 deals with the effect of high, medium, low, and no egg production on the behavior of layers 8 and 9. As shown by the table, there was a wide range in the free-

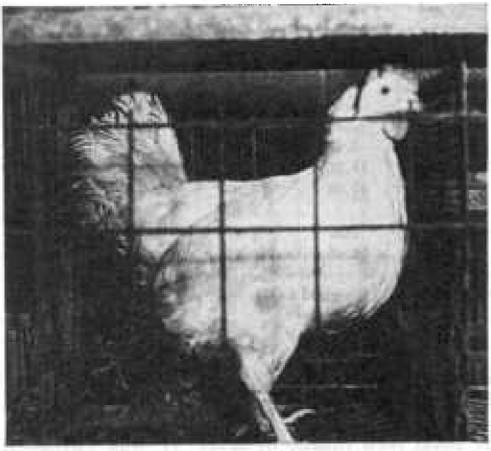

FIGURE 2.—As layer 6 appeared after 4 years and 3 months of cage life. She laid a total of 580 eggs from July 22, 1934, to November 6, 1938. Her first, second, third, and fourth years' egg production were 150, 198, 144, and 82, respectively.

choice intake of whole corn, wheat, oats, and mash or protein of these individuals while producing a comparable weight of eggs during 44 weeks. Although the total feed consumption was practically the same, it would have required 6.45 pounds more feed for layer 8 on the basis of her "2.77 pounds of feed per pound of eggs" to have produced the same weight of eggs as layer 9. The high percentage of oats consumed by layer 8 involved 1.30 pounds more of crude fiber, which, if deducted, would still leave a balance of 4.7 pounds less total feed requirement for layer 9 to produce 25.8 pounds of eggs, owing probably to her higher intake of high-protein mash and low-fiber grains. In this connection it will be noted that layer 9 consumed nearly as high a percentage of mash and protein during very low egg production as did layer 8 during high egg production. There was nothing in the subsequent behavior of these layers to account for this difference in protein intake. Both layers required about the same molting period after the 44 weeks of high egg production before resuming egg production, and both laid about the same number of eggs during the second year. However, there was a difference in longevity. Layer 8 lived 2 years, and layer 9 lived 4 years after being placed on test.

No explanation is offered for the high percentage of intake of oystershells by layer 8 or for the fact that both layers consumed a higher percentage of oystershells while in 51 or 35 percent of egg production than while in 63 percent of egg production.

Layer 8 consumed 61 percent more feed during 63 percent of egg production than during nonproduction. The average weekly body weights of both layers were greater during high than during low or no egg production. Water intake, also, was directly affected by the rate of egg production.

BEHAVIOR OF LAYERS WHEN EGG PRODUCTION CEASES

There has been much speculation about the behavior of layers just before and just after they stop laying. It is generally supposed that during high egg production many layers lose body weight until it reaches a minimum, when they are obliged to stop laying to regain their normal body weight. This contention is not substantiated by the data to follow. In table 3 is the definite story in the exact figures of the behavior of three layers just before egg production ceased and a few weeks after. The rate of egg production, water and feed intake, and body weight of these layers just previous to nonproduction were much the same as during the 43 to 54 weeks previous and were maintained until after the interruption in egg production occurred. The sequence, as will be observed, was: (1) Egg production ceased (2) a severe interruption of water and feed intake occurred either simultaneously or within 1 to 3 days afterward (3) a decline of body weight followed 1 to 3 weeks after egg production ceased. That this sequence and the behavior of these three layers were typical of what generally occurs when egg production ceases was substantiated by 54 similar instances observed in connection with other layers in these tests.

A study of the data for the three birds shows that layer 10 produced four eggs during the first 6 days of the week ending her egg-production period, and laid a stray egg 4 days later. The water intake was 160 grams for each of the 2 days previous to, and the day following, the first interruption of egg production. The average water intake 3 days previous to the day on which the one stray egg was laid was 130 grams. Here it is evident that the real break in egg production occurred 4 days previous to the day on which the last stray egg was laid. Even so, the total feed consumption was maintained during the week of the one stray egg, but during the week following there was a severe break in total feed intake, which began to affect body weight a week later. Although the total feed intake was not affected until a week after the break in egg production, there was a shift from mash to grain as soon as egg production ceased. The consumption of chopped alfalfa was the only part of the ration not affected when egg production ceased.

The performance of layer 11 was similar to that of layer 10 except that the break in egg production of layer 11 was abrupt and final. Her water intake was 210 grams during the day of her last egg and averaged 223 grams during the week preceding, whereas her water intake during the day after the last egg was 140 grams and averaged 147 grams during the week following. Obviously, water intake was not affected until the day after the last egg. As was the case with layer 10, although there was no less total feed intake during the first week of nonproduction, there was an increased consumption of whole grain and a decreased intake of mash concentrate. It was not until the second week after egg production ceased that the total feed intake of layer 11 was curtailed, and it was not until after 3 weeks that the decline in body weight occurred.

TABLE 2.—*Feed and water intake of birds 8 and 9, as affected by high, medium, low, and no egg production*

Item	Bird 8 with indicated egg production			Bird 9 with indicated egg production		
	High	Medium	None	High	Low	Very low
Duration of test, weeks	44	25	20	44	44	20
Number of eggs	195	89	1	196	107	10
Egg production, percent	63	51	......	63	35	......
Weight of eggs, pounds	23.47	10.67	......	25.80	15.06	1.29
Whole grain fed, percent:[1]						
Corn	10.83	15.69	14.29	5.72	21.17	2.94
Wheat	37.92	43.29	62.06	62.52	46.83	74.84
Oats	32.02	30.40	14.05	5.84	8.52	4.46
Total	80.77	89.38	90.40	74.08	76.52	82.24
Mash concentrate fed, percent:[1]						
Meat scrap[2] (60 percent)	11.53	6.38	5.76	15.55	14.09	10.66
Dried skim milk (20 percent)	3.85	2.12	1.92	5.18	4.70	3.55
Wheat bran (20 percent)	3.85	2.12	1.92	5.18	4.70	3.55
Total	19.23	10.62	9.60	25.92	23.48	17.76
Alfalfa hay fed, percent[3]	6.83	17.74	6.27	2.66	5.09	1.81
Protein fed, percent	17.34	14.83	14.79	21.48	18.17	17.12
Salt fed, percent	.19	.17	.09	.25	.23	.17
Oystershell fed, percent[4]	9.52	14.10	.88	5.97	6.43	3.76
Granite grit fed, percent[4]	7.67	5.76	3.41	1.81	.93	1.02
Total feed intake during experiment, pounds[5]	65.00	29.05	18.34	64.29	58.90	24.69
Rate per year, pounds	76.82	60.42	47.68	76.00	69.60	64.94
Feed per pound of eggs, pounds[5]	2.77	2.72	......	2.49	3.91	......
Water intake times total feed[5]	1.94	1.54	1.36	2.21	1.77	1.57
Average body weight, pounds[6]	4.22	4.22	4.15	4.43	4.19	4.16

[1] Percentage of total feed exclusive of salt, oystershell, granite grit, cod-liver oil, and chopped alfalfa hay.
[2] 50-55 percent protein.
[3] Chopped and fed ad libitum.
[4] Of total feed.
[5] Excluding oystershell, granite grit, and alfalfa hay; including cod-liver oil fed in the proportion of 1 percent of total feed.
[6] Average of weekly weights.

BEHAVIOR OF THE QUICK MOLTER

Layer 12 was an exceptional individual—a precocious layer and a quick molter. She began laying December 1, 1935, and produced 263 eggs during the 54 weeks to follow without missing a single week. After a pause of between 5 and 6 weeks beginning December 7, 1936, she resumed production January 17, 1937, for another 18 weeks of uninterrupted production of 75 eggs, making a total of 338 eggs before the next pause in egg production, May 23, 1937. After the first pause on December 7, 1936, it was not until December 20, 1936, that she showed signs of molting. During the following week she dropped practically all her feathers, and she had a new coat of feathers January 17, 1937, when she began to lay.

This bird was a quick molter. What did she eat when not laying and during the period of rapid growth of a new coat of feathers? As soon as egg production ceased there was a severe curtailment of mash intake for a period of 3 weeks. During the first week of nonproduction the total feed intake was little less than usual, owing to the increased consumption of corn and oats. Attention is called to the high intake of protein mash concentrate (40 percent) during the 3 weeks previous to resumption of egg production and when the heaviest growth of feathers was taking place. It was not until egg production began that there was a noticeable increase in body weight.

TABLE 3.—*Water and feed intake and body weight of Single-Comb White Leghorn pullet layers immediately before and after egg production ceased*

Bird No.	Eggs per week	Weekly intake of—										Weekly body weight
		Water	Oyster-shell	Granite grit	Alfalfa[1]	Corn	Wheat	Oats	Total grain	Mash	Total feed[2]	
	Number	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*	*Grams*
10	5	1,150	80	20	54	....	310	180	490	[3]110	654	2,050
	3	1,090	80	10	30	30	280	210	520	110	660	1,990
	4	1,030	60	10	44	10	310	170	490	120	654	2,090
	[4]1	820	30	30	42	90	270	240	600	100	742	2,100
	0	480	....	....	20	20	100	100	220	30	270	2,080
	0	520	10	20	30	10	20	80	110	40	180	1,970
	0	730	....	30	20	10	20	20	50	90	160	1,870
	0	780	....	....	30	....	50	120	170	120	320	1,800
11	4	1,440	40	....	4	....	470	30	500	[3]130	634	1,920
	5	1,420	50	10	16	70	370	30	470	190	676	1,960
	5	1,110	50	20	10	....	610	20	630	150	790	1,950
	4	1,340	40	....	10	....	500	30	530	130	670	1,960
	[5]0	1,080	....	....	10	50	620	....	670	100	780	1,950
	0	860	10	10	10	20	260	10	290	90	390	2,020
	0	760	....	....	20	....	210	10	220	60	300	1,900
	0	520	....	10	30	10	290	10	310	40	380	1,740
	0	920	20	10	8	....	150	....	150	160	318	1,500
	0	2,020	10	....	10	80	340	....	420	310	740	1,440
	0	1,260	....	10	....	....	780	70	850	150	1,000	1,640
	1	1,370	50	10	10	....	500	30	530	160	700	1,810
12	5	[6]	30	20	[7]	300	150	10	460	[8]290	750	2,480
	5	....	30	....	....	270	180	....	450	250	700	2,480
	4	....	50	10	....	250	150	....	400	290	690	2,470
	4	....	40	50	....	320	140	10	470	220	690	2,390
	4	....	30	40	....	400	190	10	600	200	800	2,420
	4	....	40	40	....	360	150	....	510	210	720	2,460
	3	....	60	10	....	340	120	....	460	220	680	2,440
	[9]1	....	....	30	....	360	80	110	550	80	630	2,470
	0	....	....	10	....	60	40	....	100	90	190	2,360
	0	....	....	20	....	70	70	....	140	110	250	2,150
	0	....	....	40	....	250	80	....	330	290	620	1,920
	0	....	....	30	....	400	190	....	590	480	1,070	1,930
	1	....	30	....	....	400	150	....	550	470	1,020	2,140
	5	....	40	50	....	370	240	....	610	350	960	2,340

[1] Chopped.
[2] Including 1 percent of cod-liver oil.
[3] Mash concentrate (40 percent protein) composed of meat scrap 60 percent, dried skim milk 20, wheat bran 20, salt 1.
[4] Laid 195 eggs during preceding 43 weeks.
[5] Laid 200 eggs during preceding 44 weeks.
[6] Not recorded.
[7] 5 percent in laying mash.
[8] Laying mash, 19 percent protein.
[9] Laid 263 eggs during preceding 54 weeks.

SUMMARY

The dearth of information concerning individual layers prompted the beginning of individual studies of 12 layers at the Ohio station at Wooster in 1933. Much interesting data have been obtained during the last 5 years.

In an individual comparison of three layers that

received an all-mash ration during 36 weeks in which the egg production was comparable, the feed intake was similar when the slight differences in body weight and weight of eggs produced were taken into consideration. Contrary to this finding was the wide variation in the proportion of the feed ingredients and the protein intake of the four layers that received the free choice of whole grain and mash.

That the rate of egg production directly affected the proportion of whole grain to mash consumed and the intake of water, total feed, and oystershells, was shown by a study of the same individuals when in high, medium, low or no egg production. The total feed consumed by one layer during 63 percent of egg production was 61 percent greater than during nonproduction.

A detailed study of three layers reveals the critical readjustment of bodily functions that a layer must undergo when egg production ceases. Contrary to popular opinion, there was maintenance or gradual increase of body weight of the layers during high egg production and until 1 to 3 weeks after egg production ceased.

SQUAB CHICKENS—AN OUTLET FOR EXCESS COCKERELS[1]

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Chicken meat is produced very largely by farm flocks as a byproduct of egg production. Chicks are raised to replace the layers, the cockerels being sold as broilers, fryers, or roasters. Only in highly specialized areas, such as the Del-Mar-Va Peninsula (Delaware, Maryland, Virginia), has broiler production been very profitable. For example, a 5-year survey of Michigan farms by Wright (*15*)[2] has shown an average loss of 1.9 cents per pound of broiler. According to Philips (*8*), only early cockerels were sold at a profit, and in the experiments of Charles (*3*), four of five lots of broilers netted insufficient profit to warrant participation in this business. Any loss on the broilers is charged to pullet production and therefore becomes part of the cost of eggs.

An analysis of the items involved in broiler production has shown that the cost of feed represents by far the greatest outlay, being 47.8 percent of the total costs in Michigan, 54.5 percent in Indiana (*8*, *9*), 46.8 percent in Pennsylvania (*3*), and in the Del-Mar-Va area (*10*, *11*) 53.5 percent, or 80.5 percent of the cost of production.

If the production of poultry meat is to be made more profitable, this largest single item of expense, feed, should be carefully scrutinized. Offhand, it would seem that the quantity of feed is not amenable to reduction, which statement is true if birds have been fed good rations and marketed at the customary weights. It is recognized by nutritionists, however, that the younger the animal, the better is its feed utilization. If it were possible to market birds at lighter weights, the cost of feed per pound of bird could be lessened to some extent. Preliminary work showed that a live weight of 1 to 1.25 pounds was about the minimum that would provide a satisfactory product for the consumer. This suggested a possible, profitable outlet for surplus sexed cockerels, "started" chicks (several-week-old chicks at hatchery), and even culls, of which in some years there is such an abundance that they are destroyed at the hatchery.

The purpose of this report, therefore, is to outline some of the features connected with the production and preparation of squab chickens and to point out possible outlets for this type of product.

Squab chickens are not new to the industry, for in the trade, birds weighing less than 1.5 pounds are called squab broilers; but the demand for them, especially during the summer months when they are most plentiful, has not developed to the same extent as for heavier classes of birds. After discussing this matter with chefs and stewards, we reached the opinion that there are several reasons for this lack of demand: First, the customary method of preparation by splitting in halves provides too small a portion to satisfy either the eye or the appetite; second, the less common process of boning is so expensive that its use is limited to a narrow market of high-priced club and hotel dining rooms; third, it is claimed that the flavor of squab chickens is not so pronounced as that of older birds. It is believed that these objections have been overcome by preparing and serving the birds whole, in a manner described later.

PRODUCTION

Available data indicate that there is a diminishing return in live weight per pound of feed consumed (*1*, *12*). For example, Jull and Titus (*6*) found that for each successive kilogram of feed consumed, the increase in live weight was 90.7 percent of the preceding increase. Waite (*14*) determined the total feed consumed per pound of chicken at weekly intervals for 35 Leghorns grown in close confinement, and his data show that this increased progressively, being, at the tenth week, more than four times that at the first

[1] Published with the permission of the director of the experiment station as Journal Article No. 348 (n.s.).

[2] Italicized numerals in parentheses refer to Literature Cited, p. 452.

week. Heuser and Andrews (*4*) have obtained similar data for a longer period, which likewise clearly show that the greatest gain per pound of feed occurs when the bird is young.

By the use of the data of Heuser and Andrews, the rate of feed utilization has been calculated at 6, 12, 18, and 24 weeks of age in order to obtain some indication of the relative capacities of birds of market sizes—squabs, broilers, fryers, and roasters—for converting feed into poultry meat (table 1). It is evident that these 6-week-old chickens (called, for convenience, squab chickens although slightly underweight) utilize feed nearly twice as efficiently as broilers and three to five times as well as fryers or roasters.

TABLE 1.—*Feed consumption of Leghorns at various ages computed from data of Heuser and Andrews* (*4*)

Age of chickens (weeks)	Class	Sex	Average weight	Feed consumed— Per pound of chicken	Per pound of gain for previous 2 weeks
			Pounds	*Pounds*	*Pounds*
6	Squab	Male Female	0.75	2.74	3.33
12	Broiler	Male	2.35	3.69	5.65
		Female	1.71	4.20	7.48
18	Fryer	Male	3.45	4.78	10.70
		Female	2.69	5.19	7.77
24	Roaster	Male	4.19	6.10	15.60
		Female	3.36	6.26	14.90

As has been shown in the foregoing, the cost of feed is the greatest single item of expense in meat production. The question, therefore, arises whether the slow but efficient gain in weight of the squab chicken is more economical than the more rapid but less efficient gain of the broiler. The answer to this question is complicated by several factors, described in the following paragraphs.

Price trend.—Although the price per pound received for the larger birds is generally slightly greater, the trend is downward from spring through summer, the decline being greatest from May to June (*13*). In spring and summer, chickens are growing on a "falling market," and it requires judgment to determine at a particular time whether it is more profitable to sell or to hold them for additional growth. The squab chicken has a slight advantage in this respect, in that it is always sold at the earliest stage at which chicken meat can be marketed.

Turnovers per year.—The approximate time required to grow the first pound of Leghorn chicken is 7 weeks; the second pound, 4 weeks; the third pound, 3 weeks; the fourth pound, 4 weeks; the fifth pound, 5 weeks. Thus it is necessary to hold the birds less than two-thirds as long for the second pound and less than one-half as long for the third pound as for the first, but space requirements, equipment, and labor costs for larger-sized birds will be more than proportionately greater, as shown later. Since the production of squab chickens requires a shorter time, it permits more turnovers per year, a factor which can add considerably to the profitability of such an enterprise if done on a large scale.

Comparative space requirements for broiler and squab chickens.—The minimum space requirements of broiler and squab chickens have been calculated on the basis of equal live weights produced in the same time, using the floor area and volume requirements per chick recommended by Jull (*5, p. 196*) for chickens of various ages. To make the comparison on the same basis, it is assumed that the birds are moved every 3 weeks to an area large enough to carry them to the end of the interval. Space was not provided for birds dying during the period. The mortality figures of Poffenberger, DeVault, and Hamilton (*10*) were plotted to obtain values for the four 3-week periods. The feed-consumption data of Heuser and Andrews (*4*) were used for these same intervals.

TABLE 2.—*Space required to produce 12-week-old broilers and 6-week-old squab chickens of equivalent weight*

Age of birds	Mortality	Chicks starting each interval for— Broilers	Squabs	Area required for— 1,000 birds[1]	Broiler chicks	Squab Chicks	Volume[2] required for— Broiler chicks: Leghorn	Broiler chicks: American breeds[3]	Squab chicks: Leghorn	Squab chicks: American breeds
Weeks	*Percent*	*Number*	*Number*	*Square yards*	*Square yards*	*Square yards*	*Cubic yards*	*Cubic yards*	*Cubic yards*	*Cubic yards*
0–3	7.4	1,205	3,059	15.4	17.2	43.7	3.1	3.0	8.8	8.7
3–6	3.7	1,116	2,833	23.1	24.8	62.9	7.2	8.6	19.6	23.8
6–9	3.7	1,071	....	42.4	43.5	....	13.9	15.7	....	....
9–12	2.2	1,026	....	57.8	57.8	....	19.6	23.8	....	....
End 12th	17.0	1,000	2,720	....	143.3	106.6	43.8	51.1	28.4	32.5

[1] Recommendations of Jull (*5, p. 196*).
[2] 0.963 cubic yard per 1,000 pounds (Jull).
[3] Rhode Island Reds, Plymouth Rocks, and White Wyandottes.

To produce continuously every third week 1,000 12-week-old broilers weighing 2,031 pounds, it is necessary to start 1,205 baby chicks to take care of the average mortality for the period. An equal weight of squab (6-week-old) chickens at the same interval requires 2,720 birds, necessitating the starting of 3,059 baby chicks. From the data in table 2, it is evident that 25.6 percent less floor area and an average of 35.9 percent less volume are required to produce 6-week-old birds equivalent in weight to 12-week-old birds on this basis. On the other hand, 2.5 times as much area would have to be heated for squabs as for broilers.

Feed consumption for equal weights of birds in a definite time.—When broiler and squab chickens are compared on the basis of equal live weight marketed every third week, squab chickens showed a greater efficiency in feed utilization than broilers of the same breed. Leghorn squab chickens consumed 30.8 percent less feed, and those of the American breeds (Rhode Island Reds, Plymouth Rocks, and White Wyandottes) 32.8 percent less feed, than the corresponding broilers. Similar calculations indicate that Leghorn squab chickens used 41.4 and 54.2 percent less feed than male fryers and roasters of the same breed.

Relation of mortality to broiler and squab production.—For the four 3-week periods, the mortality decreased from 7.4 to 2.2 percent (table 3). Although 11.1 percent of mortality occurred during the first 6 weeks as compared with 5.9 percent for the second 6 weeks, there is a considerably greater investment per bird during the latter period. Thus, despite the fact that about 1.5 squab chicks die for each broiler chick, their value is much less. Although chicks dying before reaching broiler age consumed more than twice as much feed as those dying before reaching the age of squab chickens, this difference is not very significant in determining the efficiency of feed utilization for the two market classes of poultry.

Effect of breed on squab production.—Barred Rock chicks or crossbreeds are used by most broiler plants because they are superior to the Leghorn in feed utilization and body conformation. However, Leghorns from the egg-producing areas of the country furnish an excessive quantity of poultry meat, which is inferior in quality to that of the heavier breeds at the usual weights marketed. Up to 1 to 1.25 pounds, fortunately, there is little difference between the breeds either in the efficiency of feed utilization or in body conformation, and thus there is no breed preference for squab production. Nevertheless, if Leghorns were marketed as squab chickens, they would be at their best rather than appearing on the market as older birds of poor quality, as at present. It is anticipated that the marketing of Leghorns as squab chickens would result in uniformly higher quality in the heavier classes of poultry—a result which would be desirable for the industry in general.

TABLE 3.—*Feed consumption of 12-week-old broilers and the equivalent weight of 6-week-old squab chickens*

Age of chickens (weeks)	Weight per 1,000 birds	Mortality		Feed per 1,000 birds to—		Broiler chicks			Squab chicks			
		Period	Total	Median Period	End Period	Started	Died	Feed used by dead birds	Started	Died	Feed used by— Dead birds	Live birds
	Pounds	*Percent*	*Percent*	*Pounds*	*Pounds*	*Number*	*Number*	*Pounds*	*Number*	*Number*	*Pounds*	*Pounds*
Leghorn Breed												
0-3	320	7.4	7.4	234	627	1,205	89	20.8	3,059	226	53.0	1,707
3-6	747	3.7	11.1	1,256	2,049	1,116	45	55.9	2,833	113	142.0	5,573
6-9	1,442	3.7	14.8	3,241	4,831	1,071	45	144.2	....	....	....	....
9-12	2,031	2.2	17.0	6,516	7,932	1,026	26	172.7	....	....	....	....
End 12th						1,000	205	393.6	2,720	339	195.0	....
American breeds[1]												
0-3	314	7.4	7.4	201	575	1,205	89	18.0	3,103	229	48.3	1,652
3-6	894	3.7	11.1	1,265	2,281	1,116	45	56.3	2,874	115	145.3	6,293
6-9	1,628	3.7	14.8	3,631	5,300	1,071	45	161.6	....	....	....	....
9-12	2,466	2.2	17.0	7,148	9,223	1,026	26	189.4	....	....	....	....
End 12th						1,000	205	425.3	2,759	344	193.6	....

[1] Rhode Island Reds, Plymouth Rocks, and White Wyandottes.

Relative number of baby chicks required.—The marketing of squab chickens, from the nature of the enterprise, would require several times the number of baby chicks to produce the same quantity of chicken meat consumed at present. For example, only one baby chick marketed as a roaster is required for six servings of meat, whereas six baby chicks are needed to furnish the equivalent as squab chicken. Table 3 shows that it takes 2.72 times as many baby chicks to produce squab chickens equal in weight to broilers. Hatcherymen, therefore, have much to gain. Because squab-chicken production requires more baby chicks, it would extend the hatching season and result in a greater utilization of hatching capacity.

Although chick sexing has created a cheap supply of day-old cockerels, the sexing technique is not entirely perfected; consequently, it may be expected that from 5 to 10 percent of the "cockerels" will turn out to be pullets with several times the value of the male.

Comparative costs of broiler and squab production.—According to table 3, squab chickens are produced at a saving of 35.9 percent in the quantity of feed required. The cost of a good broiler ration over a period of years averages about $2.50 per 100 pounds in Michigan. It is calculated that this economy alone would allow payment of $3.45 per 100 for the extra Leghorn baby chicks required, which is above usual prices for sexed cockerels. For the American breeds this would allow $4.17 per 100. The price that can be paid for baby chicks was obtained in a comparison of 6- and 12-week-old chickens; compared with older birds this price will be higher.

Labor costs of production and processing are not available as yet, but it is believed that only in the former will there be an advantage for the squab chicken; space and volume requirements are definitely in their favor as was shown previously. Assuming that the squab chicken would have an equivalent marketing opportunity and selling price per pound as the broiler, it appears that excess cockerels can be economically grown to squab chickens, particularly if space, labor, and equipment are not available to grow them to heavier classes of poultry.

DRESSING AND PREPARATION OF SQUAB CHICKEN

Chickens from 1 to 1.25 pounds of live weight are bled, scalded, and plucked in the usual manner, and the pinfeathers removed, preferably by waxing. To prepare for cooking, the shanks and feet, and oil gland are cut off. After the skin has been pulled toward the base of the neck, the neck is severed close to the body. This precaution is taken to improve the cooked appearance of the squab, as the skin shrinks when cooked. The vent is clipped off with scissors, and a transverse slit about 1.5 inches long is made about an inch above the vent. By hooking the gizzard with the forefinger and pulling slowly, the viscera (except the heart, liver, and lungs) are drawn through the upper slit. The liver is then removed and the bird washed. The wings are folded behind the back and the ends of the legs slipped through the upper slit into the lower abdomen, which forms a pocket holding them close to the body (fig. 1).

If a waxing outfit is not available to remove the pinfeathers, the plucking of squab chickens is time consuming. To speed up this operation, skinning has been found to be much faster and may be used as an alternative method for fresh-killed squab chickens. By this procedure, which differs somewhat from that described by Bruckner (2), about 20 to 25 birds can easily be killed, skinned, drawn, and washed per hour by an individual. For skinning, the birds are beheaded, bled out, and the feet and shanks, neck, and wings at the first joint removed. The skin is snipped on the abdomen, pulled up over the breast slowly, and stripped from the breast, upper back, and wings in one piece, as it tears along and behind the feather tract on the sides; the remainder of the skin, so tender it tears at the vent, is stripped off in a second piece. The abdominal wall is then slit from vent to lower end of keel, and the entrails are removed as previously described, after which the vent and tail are trimmed off. The legs are held close to the body by means of a skewer through the hip cartilage. As already stated, skinning is much the faster method, but it is subject to the criticism that it removes a flavorsome portion of the carcass, requires extra treatment of

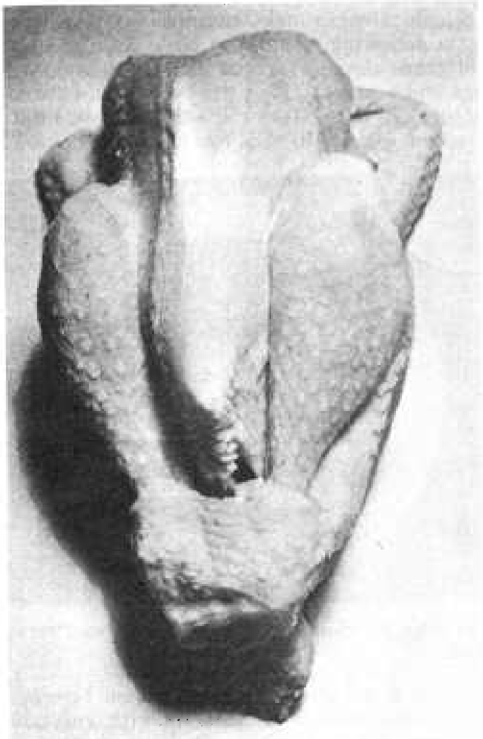

FIGURE 1.—Full-dressed squab chicken showing the method of holding the legs close to the body.

the birds at the time of cooking, and reduces the possible storage period of the birds. Nevertheless, the product is still very desirable because it receives a new skin of a more nutritious nature before cooking, which compensates to a high degree for the loss noted. The percentage of edible meat is slightly less for squab than for heavier chickens (7).

Cooking and serving.—In developing recipes for cooking and serving the squab chicken, the objective has been to create a delicacy having considerable "eye appeal." As mentioned previously, it is believed that much of the discrimination against this product is caused by unsatisfactory methods of preparing and serving. In order to learn how to overcome this prejudice, preliminary studies were made with small lots of squab chickens to determine the best manner of cooking and serving. It was soon decided to cater to the fine trade by serving the squab chicken whole in the enticing ways described (fig. 2). By so doing, each person receives both white and dark meat.

Squab-chicken meat is more juicy and tender than that of mature chickens and contains a higher proportion of protein and proteinlike substances, which make it more digestible. It has a low fat content and thus has only half the number of calories per pound as meat of older birds, an item which may be of some importance in a delicacy.

Squab chickens make an appealing dish served in the following ways: The birds may be stuffed and those that have been skinned treated with eggs and crumbs. They are cooked in a steamer for one-half hour, after which they may be roasted in a hot oven (450° F.) for 15 minutes, fried in deep fat 6 minutes to a deep golden brown, or baked uncovered in a casserole with vegetables and gravy for 10 minutes. Preliminary steaming reduces the time of cooking one-half and prevents desiccation. Roasted and en casserole squab chickens are especially suited for banquets, since they may be prepared ahead of time in large numbers, whereas the fried squab chicken is more adapted to small groups since it should be prepared as ordered. A highly seasoned stuffing is desirable since it makes the dish more substantial and accentuates the flavor of the meat; sage, onions, parsley, nuts, and mushrooms are good additions to a stuffing containing considerable fat and little or no liquid. To emphasize chicken flavor, melted chicken fat may be used in place of butter in the dressing.

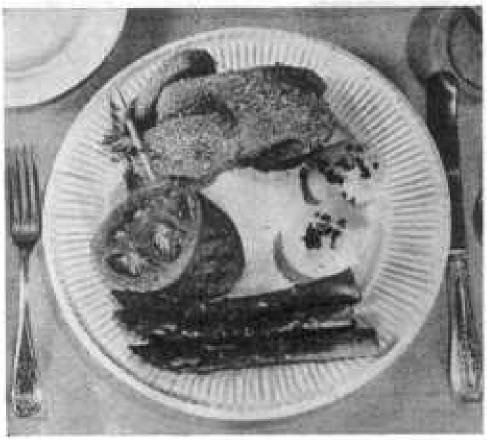

FIGURE 2.—Squab chicken roasted and served whole.

SUMMARY

Surplus day-old cockerels may be economically grown to 1 to 1.25 pounds of live weight and marketed as squab chicken when space, labor, equipment, or financial requirements do not permit their growth to heavier market classes of poultry. To produce equal live weights of broiler (12-week-old) and squab (6-week-old) chickens, 31.8 percent less feed, 25.6 percent less floor area, and 35.9 percent less volume are required for the squab chickens. On the other hand, 2.5 times as much area would have to be heated for these birds. Despite a higher mortality rate of squab chickens than of broilers, the greater investment per casualty in the latter more than outweighs the loss of a larger number of less expensive squab chicks.

Leghorns weighing 1 to 1.25 pounds are as satisfactory in body conformation as other breeds of the same weights. The marketing of Leghorn cockerels as squab chickens would produce uniformly higher quality in the heavier classes of poultry because this practice would result in Leghorns being sold at their best rather than allowing them to grow into older birds of poorer quality.

Of particular interest to hatcherymen is the fact that two to three times as many baby chicks would be required to produce the same weight of squab chickens now supplied by the heavier classes of poultry.

Methods of dressing and preparation for serving are described in detail.

Squab chickens, when served whole, make an "eye appealing" dish particularly suited for hotel and banquet service.

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DAS EIGEWICHT IN SEINER BEZIEHUNG ZU SEINEN BESTANDTEILEN

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Ueber das Eigewicht in seiner Beziehung zu den Bestandteilen liegen zwar eine Reihe von Untersuchungen vor Curtis 1914, Atwood and Weakley 1917, Jull 1924, Asmundson 1931, Philpott 1934, Křiženecký 1934, Meszáros 1934, Ohlson 1936 u. a.; sie verfolgten jedoch meistens nur diese Beziehungen im ersten Legejahre und nur im frischen Zustande.

Die vorliegende Arbeit bringt die gesamte Lebens-Legeleistung—von Legebeginn bis zum natürlichen Absterben der Hennen maximal 9 Jahre (siehe Podhradský 1936). Zur Untersuchung kamen je 2 Hennen von 6 verschiedenen Rassen; eliminiert wurden jedoch 6 Hühner wegen zu kurzer Lebensdauer (weniger als zwei Jahre).

Jedes gelegte Ei wurde gewogen (neben anderen Bestimmungen), in seine Bestandteile getrennt, getrocknet und verascht nach üblichen Methoden. Die Verluste bei der Trennung betrugen maximal 0.5 prozent hauptsächlich verursacht durch Verdunstung, Anhaften an den Pipetten, sie sind im Durchschnitt jedoch noch geringer.

Die gewonnenen Zahlen: Gesamtgewicht, Gewicht der einzelnen Bestandteile, frisch, trocken und verascht,—absolut und relativ zum Gesamtgewicht und zum Gewichte der korrespondierenden Bestandteile, wurden für jede Henne korrelationsstatistisch weiter verarbeitet und zwar von 3 Gesichtspunkten aus:

1. auf den Zusammenhang: Gesamtgewicht des Eies x absolute Gewichte der Bestandteile im frischen Zustande, Trockensubstanz und Asche.

Da diese Untersuchungen jedoch nur die gegenseitigen Beziehungen der einzelnen Merkmale zu betrachten gestatten, nichts aber über das Verhalten der Zusammensetzung der Eier aussagen kann, welche sowohl durch den prozentuellen Anteil der einzelnen Teile vom ganzen Eigewicht, als auch durch den prozentuellen Anteil der Trockensubstanz und Asche von der entsprechenden frischen Substanz resp. auch den prozentuellen Anteil der Asche von der Trockensubstanz der korrespondierenden Bestandteile bestimmt wird, wurde auch

2. der Zusammenhang: Gesamteigewicht x prozentischer Anteil der Bestandteile am Gesamtgewicht, resp.

3. die Beziehung: Gesamteigewicht x prozentischer Anteil der Trockensubstanz und Asche von den Gewicht der frischen Bestandteile resp. dem prozentischen Anteil der Asche von der Rrockensubstanz bestimmt.

Im weiteren gebe ich nur die Durchschnittsgrössen der Korrelationskoeffizienten wieder:

TABELLE 1.—*Korrelation zwischen Gesamteigewicht und den absoluten Gewichten der Bestandteile (Frisch, Trockensubstanz und Asche)*

	Korrelationskoeffizienten	
	Durchschnitt	Variationsweite
Gesamteigewicht: × absol. Gewicht (frisch)		
Eiklar	0.885	0.825 bis 0.937
Eidotter	0.762	0.716 bis 0.895
Eischale	0.582	0.432 bis 0.767
Gesamteigewicht: × absol. Gewicht (Trockensubstanz)		
Eiklar	0.465	0.359 bis 0.627
Eidotter	0.759	0.692 bis 0.889
Eischale	0.572	0.389 bis 0.781
Gesamteigewicht: × absol. Gewicht (Asche)		
Eiklar	0.041	0.009 bis 0.072
Eidotter	0.249	0.210 bis 0.402
Eischale	0.419	0.214 bis 0.576

Es besteht also ein ausgesprochener und zwar positiver (Korrelationskoeffizient grösser als 0.5) Zusammenhang bloss zwischen Gewicht der Eier und dem absoluten Gewichte der Bestandteile, undzwar sinken die Korrelationskoeffizienten in folgender Reihenfolge: frische Substanz: Eiklar → Eidotter → Eischale; Trockensubstanz: Eidotter → Eischale → Eiweiss; Asche: Eischale → Eidotter → Eiweiss. Das Gesamteigewicht ist also in erster Linie eine Funktion der absoluten Eiweissmenge, an zweiter Stelle des Dotters.

TABELLE 2.—*Korrelation zwischen Gesamteigewicht und dem prozentischen Anteil der Bestandteile am Gesamtgewicht (Frisch, Trockensubstanz und Asche)*

	Korrelationskoeffizienten	
	Durchschnitt	Variationsweite
Gesamteigewicht: × prozent. Gewicht (frisch)		
Eiklar	+0.126	+0.330 bis −0.112
Eidotter	−0.065	+0.149 bis −0.226
Eischale	−0.098	+0.047 bis −0.223
Gesamteigewicht: × prozent. Gewicht (Trockensubstanz)		
Eiklar	−0.119	−0.024 bis −0.248
Eidotter	+0.068	+0.280 bis −0.127
Eischale	−0.064	+0.157 bis −0.223
Gesamteigewicht: × prozent. Gewicht (Asche)		
Eiklar	−0.156	−0.091 bis −0.218
Eidotter	−0.037	+0.055 bis −0.171
Eischale	+0.001	+0.182 bis −0.194

Die relativen Gewichte der Bestandteile scheinen—im Durchschnitt—vom Eigewicht wenig abhängig zu sein, obzwar individuell grosse Unterschiede bestehen; die Korrelationskoeffizienten sind verschieden (immer aber kleiner als 0.5), und nicht eindeutig (positiv und negativ). Im Lichte dieser Feststellungen werden die Eier verschiedener Herkunft, also ein Gemisch von Eiern, wie sie die Markteiern vorstellen, wo individuelle, Rassen-, Haltungs- und Fütterungsunterschiede verwischt sind, recht konstant und homogen in ihrer Zusammensetzung sein, womit die Ergegnisse der Untersuchungen von Křiženecký an Markteiern ihre Bestätigung finden. Daraus würde sich ergeben, dass die Gewichtseinheit von Eiern

TABELLE 3.—*Korrelation zwischen Gesamteigewicht und dem prozentischen Anteil der Trockensubstanz und Asche von dem frischen Gewicht der Bestandteile bestimmt*

	Korrelationskoeffizienten	
	Durchschnitt	Variationsweite
Gesamteigewicht:		
× prozent. Trockensubstanz		
Eiklar	−0.164	−0.114 bis −0.236
Eidotter	+0.269	+0.140 bis +0.460
Eischale	+0.094	+0.189 bis −0.047
Gesamteigewicht		
× prozent. Asche		
Eiklar	−0.147	−0.026 bis −0.196
Eidotter	−0.018	+0.034 bis −0.073
Eischale	+0.074	+0.186 bis −0.003

TABELLE 4.—*Korrelation zwischen Gesamteigewicht und dem prozentischen Anteil der Asche von dem Gewicht der Trockensubstanz der Bestandteile bestimmt*

	Korrelationskoeffizienten	
	Durchschnitt	Variationsweite
Gesamteigewicht:		
× prozent. Asche		
Eiklar	−0.121	−0.063 bis −0.160
Eidotter	−0.028	−0.004 bis −0.055
Eischale	+0.007	−0.057 bis +0.097

in ihrer Zusammensetzung gleich bleibt, einerlei ob es sich um kleine oder grosse Eier handelt, was besonders für den Eierhandel wichtig ist.

Der relative Anteil der Gewichte der Bestandteile von den entsprechenden Bestandteilen frisch oder trocken ist korrelativ vom Eigewicht wenig abhängig; die Korrelationskoeffizienten sind zwar klein, aber für den prozentuellen Anteil der Trockensubstanz des Eiklars (negativ) und des Eidotters (positiv) eindeutig. Daraus könnte geschlossen werden, dass die Zunahme des Gewichtes der Eier grösstenteils aus der Zunahme des Eiklars an Wasser, beim Eidotter von Trokkensubstanz (also fester Körper) beruht; parallel mit dieser Erscheinung geht im ersten Falle eine relative Abnahme der Aschensubstanz (Korrelationskoeffizient eindeutig negativ) einher, während im zweiten Falle sich der Stand der Mineralien (Asche) nicht verändert; die Korrelationskoeffizienten sind klein und nicht eindeutig—positiv und negativ. Diese Erscheinung scheint mit dem Charakter der Eibildung resp. der Bildung des Eiklars im Einklang zu sein. Die Menge—nach Gewicht—des sezernierten Eiweiss (und Eischale) hängt nicht nur von der Grösse des den Ovidukt passierenden Eidotters (Pearl 1910) und von der Fläche der eiweisssezernierenden Partie des Oviduktes (Asmundson 1931) ab, sondern ist auch wie Pearl und Curtis (1912) bei Hennen und Chomkovič (1927) bei Enten festgestellt haben, von der Menge des erst im Uterus—wo das Ei vor dem Ablegen längere Zeit verweilt—durch Osmose hinzutretenden Wasser mit darin aufgelösten Mineralien und dünnem Eiweiss durch die schon gebildeten Häute, resp. auch schon teilweise gebildete Eischale abhängig.

Die negative Abhängigkeit (negativer Korrelationskoeffizient) für den prozentuellen Anteil des Eiklars könnte also auf Grund dieser Feststellungen dadurch erklärt werden, dass die Gewichtszunahme der Eier, die hauptsächlich auf einer Zunahme von Eiklar beruht, nicht von einer relativ gleichen Zunahme von Trockensubstanz begründet ist, sondern auf einer relativ grösseren Zunahme von Wasser basiert. Es sind demnach schwerere Eier relativ ärmer an Trockensubstanz bzw. reicher an Wasser im Eiklar. Dieselbe Tendenz zeigt auch der relative Aschenanteil; er sinkt mit steigendem Gewicht. Beim Eidotter ist dies gerade umgekehrt und beruht seine relative Zunahme auf einer Zunahme der relativen Trockensubstanz. Aus den anderen Beziehungen kann nichts gefolgert werden, da die Korrelationskoeffizienten teils zu klein, teils nicht eindeutig sind.

ZUSAMMENFASSUNG

Die korrelationsstatistische Verarbeitung der Lebensleistung von 5 Hennen 3 Rassen ergab:

1. eine enge Abhängigkeit des Eigewichtes x absol. Gewichte der Bestandteile (Korrelationskoeffizient grösser als 0.5) in folgender Reihenfolge: Gewichte der frischen Substanz: Eiklar, Eidotter, Eischale; Trockensubstanz: Eidotter, Eischale, Eiweiss; Asche: Eischale, Eidotter, Eiweiss.

2. keine Abhängigkeit zwischen Eigewicht x relativ. Anteil der Bestandteile vom Gesamtgewichte (Korrelationskoeffizient kleiner als 0.5 und nicht eindeutig—positiv und negativ). Eine gewisse Beziehung scheint nur beim prozentuellen Anteil des frischen (positiv), trockenen (negativ) und veraschten (negativ) Eiklars und dem prozentuellen Anteil des frischen (meistens negativ) und trockenen (meist positiv) Dotters angedeutet zu sein.

3. keine Abhängigkeit zwischen Eigewicht x relat. Anteil der Bestandteile (trocken und verascht) von deren korrespondierenden Frisch- resp.

Trockensubstanz. Angedeutet ist bloss eine gewisse Tendenz bei der relativen Trockensubstanz des Eiklars (Korrelationskoeffizient klein aber stets negativ), resp. der relativen Trockensubstanz des Eidotters (Korrelationskoeffizient klein aber stets positiv). Aehnlich ist auch das Verhalten der Prozent Asche des Eiklars und Eidotters von der frischen Substanz resp. der Trockensubstanz bei der Prozent Asche des Eiklars.

Aus diesen Befunden könnte also kurz gefolgert werden, dass das Gesamteigewicht funktionell stark abhängig ist, hauptsächlich von dem Gewichte des Eiklars und Eidotters. Ferner, dass zwar individuell die prozentische Zusammensetzung schwankt, im Durchschnitt aber fast keine Abhängigkeit vom Eigewicht zeigt, also in einem Gemisch von Eiern verschiedener Herkunft ziemlich konstant sein wird und schliesslich, dass die Gewichtszunahme des Eiklars hauptsächlich durch Wasseraufnahme, beim Eidotter aber durch Trockensubstanzzunahme bedingt wird.

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SUMMARY

The statistical analysis of the entire egg yield of five hens of three different breeds showed the following:

A close correlation between egg weight and absolute weight of the components (correlation coefficient above 0.5) in the following order: Weights of the fresh substance—albumen, yolk, and eggshell; of dry substance—yolk, eggshell, and albumen; and of ash—eggshell, yolk, and albumen.

No correlation between egg weight and relative portion of the components of the total weight (correlation coefficient below 0.5 and not definitely positive or negative). A certain correlation seems to be indicated only in the percentage of the fresh (positive), dry (negative), and ashed (negative) albumen, and in the percentage of the fresh (mostly negative) and dry (mostly positive) yolk.

No correlation between egg weight and relative portion of the components (dry and ashed) and their corresponding fresh and dry substance. There is indicated only a certain tendency in the relative dry substance of the albumen (correlation coefficient small but always negative), and in the relative dry substance of the yolk (correlation coefficient small but always positive). The percentage of the ash of the albumen (both fresh and dry) and of the ash of the dry yolk is similar.

From these findings one may draw the conclusion that the total egg weight depends mainly upon the weights of the albumen and of the yolk. Furthermore, although the percentage of composition varies in individual cases, on the average it does not show any dependence upon the egg weight. Therefore, in eggs of different origin, the percentage of composition will be rather constant. In the albumen, an increase of weight is mainly due to an increase of water, and in the yolk it is caused by an increase of dry substance.

BREEDING ARRANGEMENTS FOR POULTRY FARMING IN THE NETHERLANDS

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Before the introduction of the modern incubators, in about 1928, which made it possible to hatch simultaneously great numbers of eggs in a very limited space, the hatcheries, for the greater part, obtained their eggs from their own poultry farms. Because of the possibility of increasing the hatching capacity to an almost unlimited extent, there arose large hatcheries, some with a capacity of hundreds of thousands of eggs every 3 weeks. In these large hatcheries it was impossible to obtain all the required hatching eggs from their own poultry farms. Additional hatching eggs had to be bought. Some of the establishments bought all their eggs and were organized exclusively as hatcheries. The keen competition caused the prices of chickens to fall considerably. It is quite comprehensible that under those circumstances several hatcheries began to buy eggs as cheaply as possible, whereby the requirements that existed in connection with the furnishing of the hatching eggs receded into the background. Also, sufficient attention was not paid to the hatching eggs themselves. The placing together of chickens from hatching eggs from all sorts of farms, where there was practically no control of the health of the stock, increased the spread of all kinds of diseases.

It was impossible for the purchasers of chicks to determine whether a certain hatchery delivered good or poor chicks, with the result that the price of the good chicks fell greatly. All this led to a decline in the quality of the poultry stock, which was manifested everywhere in 1931, 1932, and 1933. The Government in the Netherlands felt obliged to take measures to improve breeding. Therefore, in 1933 the legal breeding arrangements for poultry farming were established for the purpose of (1) improving the poultry stock and (2) influencing the size of the poultry stock.

The measures taken for the improvement of the poultry stock are the following:

ESTABLISHMENT OF A HATCHING SEASON

The hatching season was selected with the idea of hatching the chicks in the time of the year that was most favorable for them. By this regulation the late-hatched chicks are completely eliminated. Early hatched hens produce more eggs in the autumn months, which is the time when the eggs are generally most expensive. The hatching season was fixed as follows:

1934: Jan. 13 to May 3.
1935: Jan. 15 to May 17.
1936: Jan. 10 to May 10.
1937: Jan. 18 to May 8.
1938: Jan. 1 to May 8.
1939: Jan. 1 to May 7.

In other than the fixed hatching season, eggs were allowed to be hatched only for scientific investigation or exclusively for meat purposes. For this a special permit is granted.

REGULATION OF A MINIMUM SIZE FOR HATCHING EGGS

Too light hatching eggs usually result in small and weak chicks. The minimum weight for hatching eggs has been fixed at 57 grams for the laying breeds.

PROMOTION OF THE USE OF EGGS FROM GOOD BREEDS

With the breeding arrangements a division is made between poultry breeders, hatchery flocks, and hatcheries. The poultry breeders have as their task the improvement of the quality of poultry; the owners of hatchery flocks obtain chickens from the poultry breeders; the hatcheries, i.e., those in which the chicks are hatched in a mechanical way in order to produce market eggs, obtain the required hatching eggs from the hatchery flocks.

It is clear that for the establishment of an organization such as this, some years are necessary. Table 1 shows the progress which has been made.

Thus since 1935 there has been a progressive increase in the proportion of total hatching eggs obtained from poultry breeders and the hatchery flocks. In 1935, 42 percent were obtained from these sources. In 1936 the percentage had increased to 63 and in 1937 to 86.

In 1938, 89 percent of the hatching eggs were obtained from poultry breeders and hatchery flocks. In this year the remaining 11 percent, for the greater part, were hatched by those who breed exclusively on their own farms. Therefore, in the Netherlands practically all chickens are produced under controlled conditions.

To be acknowledged as a poultry breeder, the producer must have healthy stock, which, for at least 2 years, has been controlled with regard to production, by means of trap nests. Besides, the birds must be well housed and be provided with free space or with runs of at least 15 square meters for every adult bird. When all these requirements are met, the basis for a good poultry farm has been laid.

The acknowledged breeder is subject to strict directions. All the birds on his farm are carefully selected. Only those that meet the requirements are provided with a numbered and nonremovable governmental wing mark. The rejected birds must be removed from the farm immediately.

The chickens hatched on the farm of a breeder are provided with a numbered governmental mark so that, when they have been delivered to the owner of a hatchery flock, their origin can always be traced.

The young hens of the poultry breeders are examined when they are 4 or 5 months old. Only young hens and cocks that have been hatched individually, whose dams are those designated for the purpose, and that have the required outward appearance, are provided with a numbered and nonremovable governmental wing mark. All the other young birds must be disposed of by a certain date.

TABLE 1.—*Progress made in breeding arrangements, 1935–38*

Source of hatching eggs	1935		1936		1937		1938	
	Eggs	Proportion of total eggs set	Eggs	Proportion of total eggs set	Eggs	Proportion of total eggs set	Eggs	Proportion of total eggs set
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
Poultry breeders	4,106,812	18	4,631,271	21	4,904,084	21	4,816,999	18
Hatching flocks	5,412,767	24	9,423,434	42	14,994,883	65	19,052,054	71
Other farms	13,260,689	58	8,154,493	37	3,241,743	14	3,042,446	11
Total	22,780,268	100	22,209,198	100	23,140,710	100	26,911,499	100

The egg production of the approved hens must be recorded by trap-nesting, beginning with the first egg.

One of the regulations is that on February 1, just before the beginning of the hatching season, all young hens that have laid, between August 1 and February 1, less than a fixed minimum number of eggs, must be removed from the farm. The minimum production for this period is as follows:

	Number
White Leghorn	35
Brown Leghorn	25
Exchequer Leghorn	25
Rhode Island Red	25
White Wyandotte	25
Barnevelder	20
Welsumer	20

In connection with these figures, one must take into consideration that it is harmful to force production. Poultry breeders are prohibited from using artificial lights with pullets. By means of artificial lights the production is considerably increased during the winter months, but the quality of the hatching eggs is reduced.

With hens, artificial lighting is allowed from January 1. By the use of such lighting, laying occurs at a somewhat earlier date, which is desirable in order to obtain sufficient hatching eggs during the fixed hatching season, which is early in the spring. As the older hens have just had a period of rest, artificial lighting hurts them less than it does pullets.

So, on February 1 at the latest, the pullets with an insufficient winter production must be removed.

The control of the laying of the other hens continues until the birds are 1½ years old. The number of eggs laid from the first egg until the birds have reached the age stated, is considered as their annual production.

For the various breeds there has been fixed a minimum production and a minimum egg weight. Hens that do not meet these requirements must be disposed of. These minimum requirements are as follows:

Breed	Egg production	Egg weight	Broodiness
	Number	*Grams*	
Leghorn	175	57	None
Rhode Island Red	175	57	Twice
White Wyandotte	165	57	Do.
Barnevelder	160	59	Once
Welsumer	140	62	Do.

With hens whose annual production is at least 25 eggs above the fixed minimum, the average egg weight is allowed to be 1 gram less. Those hens that meet the demands for production are again examined in the autumn with regard to their outward appearance.

The poultry breeders are obliged to keep certain records. Besides, they are under the constant supervision of qualified controllers, who not only observe the housing and management but also the condition of the birds. At the same time there is a survey as a result of which all that is objectional is removed from the farm. Examination for pullorum disease is now obligatory for all poultry breeders. Figure 1 shows the status of this disease in 1938. From this figure it appears that on only about 3 percent of these farms, the percentage of animals reacting to pullorum disease (B. W. D.) was higher than 3 percent.

Every year questionnaires are sent to all purchasers of chicks. The information received is worked into a card system, by which there is obtained a concise but clear survey of the chickens sold from each breeding farm.

Demands for the acknowledgment as poultry breeders, examination of the birds at the acknowledged farms, supervision of the management of the farms, and control of the delivered material—all these guarantee us first-class poultry breeders.

The material of the poultry breeders that is not to be used for maintenance of or additions to their flocks goes to the hatchery farms. Acknowledgment as a hatchery farm can take place only if all the birds—cocks as well as hens—originate on an acknowledged farm, if they are of a good quality and perfectly healthy, if the housing is good, and if there is free space or grass-grown runs of at least 15 square meters per adult bird.

The hatchery farms are also subject to careful control with regard to the condition and health of the birds. Here also examination for pullorum disease must be made. Before the beginning of the hatching season, all the birds are again examined by the control service and undesirable birds are removed.

At the hatchery farms the birds are kept under the most natural conditions. Artificial lighting during the winter months is prohibited here also.

The hatchery farms now supply practically all the hatching eggs necessary for the building up of the poultry stock in the Netherlands, so that utility poultry in the Netherlands originate almost entirely from farms subject to governmental control. This condition is in contrast to that of 1933, when the buyer really had no guarantee with regard to the origin of the hatching eggs or the chickens that he bought.

The influence of the arrangements is already clearly perceptible. The rate of mortality among chickens has decreased considerably. Poor breeding results are seldom recorded. Hatchability, which before the introduction of the breeding arrangements, certainly did not exceed 55 percent, have in 1938 risen to 70 percent for the eggs of the acknowledged farms.

Concerning the production of eggs, a more favorable distribution over the year has been acquired, as is shown in figure 2.

The average production per hen also has considerably increased. In 1938, there were 3½

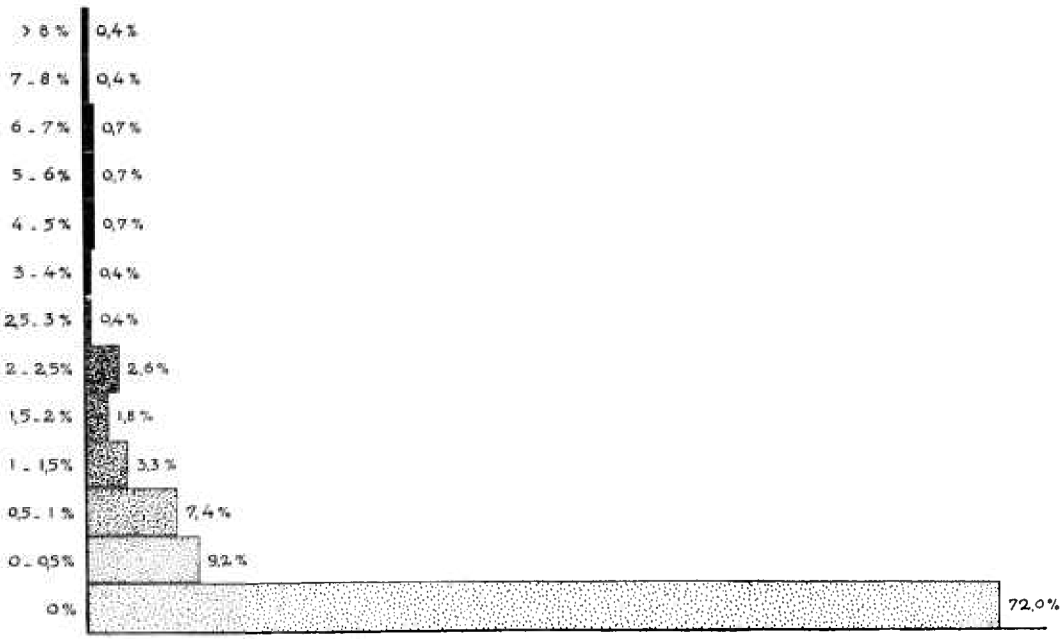

FIGURE 1.—Results of examinations, for pullorum disease, of the birds kept by the poultry breeders.

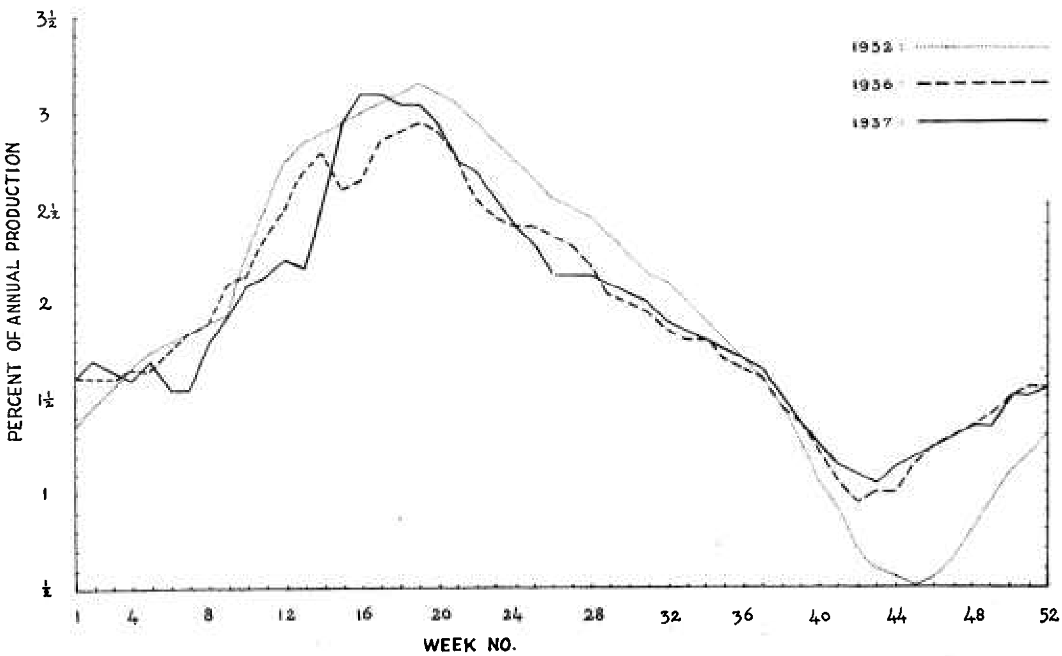

FIGURE 2.—Distribution of egg production during 1932, 1936, and 1937. In the first-mentioned year, breeding arrangements had not been made.

million laying hens less than in 1934, whereas the production has increased by nearly 300 million eggs.

The increased of sexing of 1-day-old chicks and the increasing opportunity for fraud in connection with it, resulted in a special sexing arrangement. The hatcher of chickens is obliged to mark, immediately after sexing, all the cockerel chicks on the backs of their heads with a lasting blue aniline dye over a surface of at least one square centimeter.

Only those persons who are licensed to sex chicks are permitted to do so.

SUMMARY

In order to improve the poultry stock in the Netherlands, special breeding arrangements and regulations were put into effect in 1933. In connection with these, consideration was given to the fact that the chickens that are used for breeding must be of first-class quality and must be kept in quite a different way from the chickens used in the production of eggs for consumption.

The measures taken in 1933 have resulted in improved hatchability, good breeding, an increased production with a better distribution of production over the whole year, greater egg weight, and a more favorable state of health of the birds.

EXISTENCE OF CHICKENS IN AMERICA BEFORE ITS DISCOVERY AND CONQUEST

By PROF. SALVADOR CASTELLÓ, *Director and Founder of the Spanish Official Poultry High School, Arenys de Mar, and First Vice President for Europe of the World's Poultry Science Association, Barcelona, Spain*

It has been said that at the time of the discovery and conquest of America there were no chickens in that continent. This may be true regarding the breeds of chickens known in Europe during the sixteenth and seventeenth centuries, but it cannot be affirmed as to the entire species. Although some persons are of the opinion that the existence of chickens in America before the arrival of the Spaniards is not entirely proved, the dates in this report are sufficient to furnish such proof.

This is not the first time that this matter has been reported at our Congresses of Poultry Science. I have already presented it in my report at the Congress in The Hague in 1921 and at that in Barcelona in 1924 in giving information about the existence in Chile of hens laying blue eggs. However, as this Seventh Congress is being held in America it seems opportune to present concrete dates on the history of poultry culture.

It is certainly a historical fact that the Europeans—first the Spaniards and afterward the French and the English—in their conquests of Louisiana and Canada, brought to America divers kinds of livestock, including chickens, thus perpetrating the European breeds and generalizing the breeding and exploitation in the New World. It is no less historical that, in return, there came from America to Europe the *Mexican guajolotes* (*Meleagris gallopavo*), a species unknown in the Old World until the sixteenth century, but easily acclimatized there where it is known and exploited under the name of Pavo de India in Spain, turkey in England, dindon in France, taquini in Italy, and Truthahn in Germany.

With regard to the chickens brought to America by the Spaniards, there can be no doubt that they came to the American continent with the conquerors of Mexico under Hernán Cortes. I base my affirmations on the following facts:

It is known that the expedition of this great leader was not formed in Spain but in the West Indies, discovered by Christopher Columbus in 1492, and that it started from Havana and consisted of some 700 men. It seems reasonable that at that time, in navigation, when there were no canned goods or refrigerators, the explorers would carry on board livestock and chickens, not only for their maintenance during the voyage but also for a long time afterward. However, in case we do not accept such a supposition, there is a date in history which establishes the certainty of it.

I refer to a certain letter written by Hernán Cortes to the Emperor Charles I (Charles V of Germany) on October 30, 1520, in which he gives an account of the setting up of a poultry yard and duck-breeding place in Malinaltepec (today State of Guerrero) in which there already existed 1,500 chickens and 500 ducks. In comparing dates, we find that from the time of the landing of Cortes in Vera Cruz in December 1519 to the writing of that letter only 11 months had elapsed, and if in so short a time they could have 1,500 chickens at their disposal, these either already existed in America or were brought by Hernán Cortes in considerable numbers, for it must be remembered that the discoverer burned his ships in order that his men might not conceive the idea of returning before the country was completely conquered. They thus remained entirely without communication not only with the Old World but also with the land already conquered in the West Indies. It is certain that 5 months after the landing of Cortes, a second expedition arrived in Mexico under Panfilo de Narvaez, who in 18 caravels brought some 1,000 men with whom he proposed to combat Cortes, who was supposed to be a traitor to the Emperor. This expedition surely brought with it more chickens, but as it started likewise from Havana and not from the home country, this would prove in any case that the Spaniards already possessed a great many chickens in the West Indies. This second expedition was completely defeated by Cortes, who in the chickens carried by it had found a valuable help in the dissemination of so useful and necessary a species. Thus even if there were no hens on the continent at the time of his arrival, he was able to set up the poultry farm of Malinaltepec, doubtless the first to be established in America.

In his letter to the Emperor, Hernán Cortes says that 500 ducks and as many as 1,500 chickens were placed in the poultry yard, but he does not say who placed them there, the Spaniards or the Indians. With regard to the ducks, since he adds in the mentioned documents that the Indians held them in great esteem, because they plucked their feathers yearly to make clothing for themselves, it is to be supposed that the Indians already knew this species of bird and bred them. However, with reference to the chickens, considering that there are no dates that permit belief in their existence in North America before the arrival of the Spaniards, there is no doubt that the birds kept in the poultry yards of Malinaltepec were descendants of those brought by Hernán Cortes, who in so short a time could do no better work for the dissemination of the species.

Turning now to South America, it is also historical that Francisco Pizarro, conqueror of Peru, carried cattle and poultry in his expedition. A more precise date, however, is that in connection with Don Pedro Valdivia, head of an expedition which started from Lima to carry out the conquest of Chile. He also brought with him chickens and likewise pigs and saved a couple of each species when in 1541 the city of Santiago was burned by the chief Machivaloneo. A Chili legend tells that from that cock and hen saved by Doña Ines de Suarez, the companion of Valdivia, descend the chickens of that country.

The fact that Valdivia, in his march southward, carried with him chickens of the kind known in Spain is confirmed by the reference of the Reverend Father Ricardo Capa, a Jesuit priest, who resided for many years in the Viceroy's Dominion in the south carrying out his evangelical mission, and who in his book "The Agricultural and Cattle Industry Brought to America by the Spaniards" says in the third part (pages 411 and 412) that the Castilian chickens were with the Spaniards in the Island of the Cock (Isla del Gallo). It was precisely Pedro Valdivia who had to stop for some time on the said island which, as is known, lies on the route he was following, near the coast of Panama and in the archipelago of Las Mulatas. Valdivia not only left chickens on that island, but he doubtless gave it the name it still bears on account of the excellent way in which the birds thrived there.

Father Capa says further in his book that the chickens increased so greatly in numbers everywhere that the abundance of eggs in the whole of the Viceroy's Dominion was no small resource to the traveler and merchant even in those Indian villages where food was scarcest, thanks to him who introduced the birds.

By the foregoing it is clearly shown that not only had chickens been brought from Castile to the New World at the same time of its discovery and conquest, but also that the birds rapidly increased in number, at least in the parts occupied by the Spaniards.

Let us now see what may be thought and said as to the existence of chickens or some similar wild species of bird, before the arrival of the conquerors.

Father Capa also says in his book: "Although much was heard about chickens in relation to the soldiers of the Conquest, it is an error to believe that they were like those of Castile, when only those of Paraguay and Tucuman were like them."

From this text it may be supposed that some birds existed that were considered by the soldiers to be chickens. Furthermore, in referring to those of Paraguay and Tucuman, it is clearly seen that the zone in which Father Capa reports the existence of chickens in America, although of a different kind from those of Castile, extends from west to east toward those countries that are now the Argentine and Uruguay, therefore not being limited to the coasts of the Pacific. We have, however, still more conclusive dates taken from an author of possibly more standing, for Father Capa had his book printed in Madrid in 1890, that is, 300 years after the Conquest, whereas the author of whose writings we shall now speak was a contemporary of the conquerors and therefore a more material witness.

I refer to the Reverend Father José de Acosta, also a Jesuit, a great naturalist and sociologist of the sixteenth century, author of the "Natural and Moral History of the Indies" printed in Seville in 1590, who, accompanying the conquerors, studied and wrote much on the flora and fauna, agriculture, and customs of the American Indians. Father Acosta has been called by some "the Pliny of America" with the advantage over the Latin Pliny in that the latter was influenced in many of his writings by those of other authors preceding him, whereas all Father Acosta's writings were based on his own discoveries, investigations, and studies. The famous Baron Alexander von Humboldt, to whose studies and works America owes so much, expressed in his books the greatest admiration for the cultured and capable Jesuit father. It is, therefore, understandable that credit must be given to his affirmations.

Father Acosta in chapter 35 of his book, affirms categorically the existence of chickens in the New World before its discovery saying "that there were chickens in America before the Spaniards went there" and he adds "that a clear proof of this is the fact that the Indians had in their language words by which they designed the hen and the egg, calling the former 'gualpa' and the latter 'Ronto'." Had the species become known to them through the Spaniards, it would have been natural that they would have called the birds by the names that the latter gave them, but not only was it not so, but they still use the names they had in their language. Thus the Quichuas still call the birds by the names indicated by Father Acosta, the Aymaràs maintain the name "gualpa" for the hen but call the egg "cauma." The Pascuenses have for the hen the name "uja"; for the cock, "moa"; and for the chicken, "maanga." The Arancanos call the hen "ashahual" and the cock "alka."

I may now recall what I mentioned in my report at the Barcelona Congress on the Auracanian tailless chickens, called in Chile by the name "Colloneas," a Spanish word, whereas the Indians give them the name "quetros," but which must not be confounded with the aquatic bird bearing the same name. I say this because in correct Spanish and by a name admitted by the Royal Academy of the Language, the word "quetro" is used to designate those cocks that crow badly or those that begin their crowing and cannot finish it properly. The word might, therefore, be of Araucanian origin.

In relation to the existence of chickens in America before its discovery by the Spaniards, it is a curious and interesting fact, as mentioned by the said Father Capa, that the Indians had already the custom of giving the name of "chicken" to a cowardly man, a custom still current in the Spanish language.

Father José de Acosta does not confine himself to affirming the existence of chickens on the American continent, but he also makes mention of their having been seen by the Spaniards that went to the Solomon Islands of the Archipelago of Milanesia and in saying this, he probably refers to those who about the year 1567 discovered the said islands under the navigator Mandaña.

After all these considerations which the author believes to be sufficient to prove that chickens were really in existence in America before its discovery, we may now ask: What kind of chickens may they have been or what may they have been like?

This question is more difficult to answer, but I think that as it has been said that they were not like the Castilian chickens they must have shown some very special sign to make them so different from the former. Perhaps it was the fact of their not having any tail (Dr. Ruben Bustos of Chile who knows Araucania well, tells me that 95 percent of the chickens of that region were tailless). Or perhaps it was the tufts of feathers which adorn their heads near the ears, as in the *Gallus inauris* of which I spoke on the occasion of the First World's Poultry Congress held at The Hague in 1921.

With regard to the difference in some morphological characteristic or there being some physiological difference, in spite of the discussion raised, I maintain my hypothesis that we might see it in the laying of blue or bluish-green eggs, such as not only those of the really Auracanian hens but also of certain wild- or half-wild species that are found in other American countries and even in more central parts of the continent.

It has been said that this bluish egg, so usual in Chile, was due to a mutation produced in Chilean hens in the nineteenth century. In such case, this mutation would have covered an immense zone because, as I have said before, in some Central American countries I have been assured that hens laying such colored eggs are very frequent.

After the studies and investigations of Dr. R. C. Punnett[1] of Cambridge University on the characteristics of the blue egg, it has been made known that the determining factor of the said coloring predominates over the white or brown egg, the progeny producing blue eggs when the cross is made with a breed laying white eggs, and greenish or olive-tinted eggs when the cross is made with a breed laying brown eggs.

Therefore it is not strange that when the American hen producing blue eggs was crossed with the hen brought by the Spaniards, the progeny should have produced bluish or greenish eggs, especially in Chile, where the autoctonian hen laying blue eggs predominated. Therefore I do not yet give up my hypothesis that it might very well have been a hen producing blue eggs that existed in America, either a veritable hen or a wild species like the Jao of Brazil discovered some 30 years ago by Dr. Hermann van Jehring, the eggs of which are also blue, or like the Chachalaca abundant in Mexico and in Central America and likewise laying blue eggs. The latter is often crossed with the domestic hen of that country for the production of good fighting cocks, when fecund hybrids are often obtained.

It would be very interesting to obtain in the United States or in Canada, as well as in France and England, historical dates related to the periods of their conquests in North America, so to complete or amplify those brought forward in this report.

SUMMARY

The author makes reference to his reports presented at the World's Congresses of Poultry Science in The Hague in 1921 and in Barcelona in 1924 on the existence in America of hens laying blue eggs. He also presents historical dates on the existence in America, before its discovery, of chickens which the chroniclers of the time of the conquest of the continent by the Spaniards said were different from Spanish chickens. He maintains his criterion that the species or some wild kind to be considered as chicken was already known in the New World before the arrival of the Spaniards.

On the basis of historical dates, he explains in what way and when the first importations of chickens in the countries conquered by Spain took

[1] PUNNETT, R. C. Jour. Genetics 27:465-470. 1933.

place, as well as the rapidity with which these birds were propagated from Mexico to the extreme south of the continent of America. With regards to the difference which it is said exists between the autoctonian species and the chickens brought by the conquerors, he still is of the opinion that this difference may be in the characteristic of the blue egg or in the absence of the tail in the Araucanian "quetro" hen.

The author would be glad if further dates were presented with regard to conquests made by the French and the English, since these might complete what is now known of the history of aviculture in America.

THE ORIGIN OF THE DOMESTIC PIGEON[1]

By LEON J. COLE, *Professor and Chairman of Genetics Department, University of Wisconsin, Madison, Wisconsin, U. S. A.*

Lengthy discussions of the origins of our domesticated animals have availed little in dispelling the darkness that surrounds their beginnings. In very few cases—and these for the most part the ones of relatively recent domestication, such as the turkey—do we have any certain knowledge as to the wild species (one or more) from which its domesticated form derives. The question as to whether the origin, with subsequent diversification, has been monophyletic, that is from a single wild species, or polyphyletic, incorporating elements of two or more foundation species by hybridization, has been argued pro and con in nearly every case. In some, more or less general agreement seems to have been reached; for example, in the domestic turkey, it is generally conceded that the several varieties, based almost entirely on color differences, have arisen solely by mutation from the *Meleagris gallopavo* of America, and indeed from the Mexican form of that species. On the other hand, there may be some ground for the belief that the composite of divergent types which together comprise the domestic fowl may have arisen from the amalgamation of two species of wild jungle fowl. This belief is based on the wide divergence of types of the early Asiatic and European breeds. There is, however, no direct proof that both may not have arisen from a common source. Some scientists, e.g., Lotsy, have gone so far as to maintain that hybridization of wild species has, indeed, been a major factor in natural evolution. Direct evidence is accumulating that such may be the case in some plants; in animals there seems to be little support for such an assumption.

Darwin's (1868) masterly presentation and clear analysis of the arguments for the monophyletic origin of the domestic pigeons, in his great compendium of information, has not only stood as a classic, but has apparently carried general conviction as to the soundness of the conclusions. Darwin states, as referring to the time that he wrote:

> Fanciers almost uniformly believe that the different races [of domestic pigeons] are descended from several wild stocks, whereas most naturalists believe that all are descended from the *Columbia livia* or rock-pigeon (p. 186).

Before his time some ornithologists had held different views, and since then, even though *C. livia* has been acknowledged as the principal source, the question has been raised as to whether some characters at least may not have been introduced from other species. It may be profitable to review briefly the various ideas that have been held and then to consider the question in the light of modern genetics, which has developed entirely since Darwin's time.

The knowledge of the early naturalists regarding the various species of wild and domesticated pigeons and doves was so confused that it is difficult to form a clear conception of their ideas as to relationships. The ring pigeon or cushat (*C. palumbus*), the wood pigeon or stock dove (*C. oenas*), and the Rock Pigeon or biset (*C. livia*) were jumbled together or sometimes separated, whereas the dovecote pigeon, which was practically wild but used homes provided by man as our street pigeons today use the ledges of buildings, was considered a distinct species and named *C. affinis*. Buffon (1793, p. 469) says of the ring pigeon:

> As this bird is much larger than the Biset, and as both are nearly related to the Domestic pigeon, we may suppose that the small breeds of our house-pigeons have proceeded from the Bisets, and the large breeds from the Ring Pigeons: and this conjecture is the more probable, as the ancients were in the practice of rearing and fattening Ring Pigeons.

But then he voices doubt, for he continues:

> The only circumstance that seems to oppose this idea is, that the small domestic Pigeons cross with the large sorts, while the Ring Pigeon seems not to inter-mix with the Biset, and, though they inhabit the same tracts, do not mix together.

Then continuing, in the same paragraph he concludes that,

> all the nominal species, ancient or modern, may be reduced to three, viz, the Wild Pigeon, the Ring Pigeon, and the Turtle, which have all perhaps contributed to the endless varieties of our domestic Pigeons.

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[1] Papers from the Department of Genetics, Wisconsin Agricultural Experiment Station, No. 242.

Temminck (1813) and Boitard and Corbié (1824) supported *C. livia* as the source of all domestic pigeons, and the same view was strongly championed by Selby (1835), some 30 years before Darwin's work was published. He states his opinion unequivocally but offers little evidence in its support. He says:

> It is under this species that we include not only the common pigeon, or inhabitant of the dove-cot, but all those numerous varieties, or, as they are frequently termed, races of domesticated pigeons, . . . for however diversified their forms, colour, or peculiarities of habit may be, we consider them all as having originated from a few accidental varieties of the common pigeon, and not from any cross of that bird with other species, no signs or marks whatever of such being apparent in any of the numerous varieties known to us (p. 151).

Some years later, Dixon [1851] took violent objection to any view of the origin of species or of variation that involved the derivation of one form from another. He deplores the "assumptions" that have been made by such as Temminck and Buffon and states that after due cogitation "from childhood" his "code of natural historical faith is this: that the domestic races of birds and animals are not developments, but creations" (p. 72). He does not believe "that the Dunghill Fowl is derived from the Jungle Cock, the Sheep from the Mouflon, the Dog from the Wolf, or the Runt from the Rock Dove, by any parentage whatever." I do not know whether Dixon lived to see the publication of Darwin's work, but if so it must have been a shock to see so much evidence presented beyond mere "assumptions."

Darwin's arguments may best be summed up in his own words, and the soundness of his conclusions may then be examined. He says (p. 209):

> To sum up the six foregoing arguments, which are opposed to the belief that the chief domestic races are the descendants of at least eight or nine or perhaps a dozen species; for the crossing of any less number would not yield the characteristic differences between the several races. Firstly, the improbability that so many species should still exist somewhere, but be unknown to ornithologists, or that they should have become within the historical period extinct, although man has had so little influence in exterminating the wild *C. livia*. Secondly, the improbability of man in former times having thoroughly domesticated and rendered fertile under confinement so many species. Thirdly, these supposed species having nowhere become feral. Fourthly, the extraordinary fact that man should, intentionally or by chance have chosen for domestication several species, extremely abnormal in character; and furthermore, the points of structure which render these supposed species so abnormal being now highly variable. Fifthly, the fact of all the races, though differing in many important points of structure, producing perfectly fertile mongrels; whilst all the hybrids which have been produced between even closely allied species in the pigeon-family are sterile. Sixthly, the remarkable statements just given on the tendency in all the races, both when purely bred and when crossed, to revert in numerous minute details of colouring to the character of the wild rock-pigeon, and to vary in a similar manner. To these arguments may be added the extreme improbability that a number of species formerly existed, which differed greatly from each other in some few points, but which resembled each other as closely as to the domestic races in other points of structure, in voice, and in all their habits of life. When these several facts and arguments are fairly taken into consideration, it would require an overwhelming amount of evidence to make us admit that the chief domestic races are descended from several aboriginal stocks; and of such evidence there is absolutely none.

To this he adds (p. 210):

> Finally, in favour of the belief that all the races are descended from a single stock, we have in *C. livia* a still existing and widely distributed species, which can be and has been domesticated in various countries. This species agrees in most points of structure and in all its habits of life, as well as occasionally in every detail of plumage, with the several domestic races.

Darwin considered the clear blue with black wing bars as the type of *C. livia*. He says, however (p. 189):

> Another and rather more distinct form is either truly wild or has become feral on the cliffs of England and was doubtfully named by Mr. Blyth as *C. affinis*, but is now no longer considered by him as a distinct species.

This is an entirely logical conclusion, since we now know that "*affinis*" differs from *livia* in only a further extension of black ("spread" pigment as against "clumped") so as to produce the check pattern, which is common, particularly in Homers. This pattern is, furthermore, now known to differ from the bar pattern by one principal dominant gene, *C*, as shown by Hollander (1938). Whitman (1919, vol. 1, ch. 4), on the basis of his study of the apparent evolution of pattern in pigeons, based on spots, checks, and bars, concluded that the check pattern is more primitive than the bar type and that the latter has developed from the former. It makes little difference which view we adopt, for if the *affinis* type is more primitive, *livia* could have arisen by the simple mutation of *C* to *c*. If we accept this view, the present checkered wild rock pigeons are conceivably remnants of the earlier type, in which case *C. livia* would be considered a dimorphic species with respect to color pattern. It is possible, however, that since domestication of the bar type the check pattern may have arisen by mutation and that birds of this type may have escaped and intermingled with their wild relatives. Although dominant mutations are not at all uncommon in the pigeon, as we shall note later, dimorphism of *livia* before domestication seems, on the whole, more probable.

Ghigi appears to be the only zoologist who, since Darwin's time, has seriously attempted to make a case for the polyphyletic origin of domestic pigeons. Ghigi (1908) tells us that while examining Whitman's collection of wild pigeons in 1907 he was struck by the resemblance in pattern of *C. leuconota* from Tibet to that of the domestic variety generally known as Modena. This resemblance consists primarily of colored head, wings, and tail, whereas the remainder of the body is largely white.[2] There is also a white subapical band on the tail, superficially resembling that in certain domestic breeds. Darwin (p. 188) had previously noted the resemblance of *leuconota* to certain varieties of domestic pigeons, but considered it unlikely that it should have entered into the ancestry of domestic birds because of its remote habitat in the high Himalayas. A more cogent reason is that the resemblance between it and the Modena, for example, is entirely superficial. The white pattern of the Modena and similar breeds is due to pure white areas similar to white spotting in animals generally. These white areas are sharply demarked from the colored by a clean line separating the white and colored feathers. The white patch on the rump of *C. livia* and the larger white areas of *C. leuconota* are, on the other hand, a sort of albescence. The white and color tend to merge at the borders, and the basal parts of the white feathers are dusky instead of pure white. The merging of the color and white resembles that of the colored (sepia) and white areas on a tortoise c^r (i.e., e^p c^r) guinea pig, in which the indefinite gradation is in striking contrast to regular white spotting. Furthermore, the result attained by Ghigi (1922), when he later had opportunity to cross a "gazzo di Modena" male with a female *C. leuconota,* brought out clearly the essential difference between them. The five hybrids he produced were all very similar, and all the feathers of the body were pigmented. This result demonstrates that the pattern of the Modena and of *leuconota* were not genetically homologous. It is true that the color on the head was darker than that of the body, but this is a feature which is common to a number of species of *Columba* and presumably had in these hybrids no direct relation to the dark head and white body of the Modena.

In a first set of experiments Ghigi tried to reproduce *C. livia* "by crossing the most different races of pigeons." From the results of this test he concluded that:

> When one crosses the several races of domestic pigeons, differing in size and in anatomical characters, one obtains a form intermediate between the parents, which fluctuates between the determined limits, and which does not correspond to *C. livia* except that the tail is longer and the beak is shorter and stouter.

Intermediates are naturally to be expected in characters determined by multiple factors, as are size and form. When birds of different colors are mated, however, it is rather the exception to obtain an intermediate condition in their offspring. Ghigi maintained that unless there are among the progenitors gray (= "blue") birds with black bars, like *C. livia,* the color of this species will not appear among the offspring. It is, however, entirely a matter of obtaining the proper gene combination. If Ghigi had crossed, for instance, a red pigeon of the composition *ee ss* with a black *EE Ss*, the other genes being of the normal wild type, he might have expected half the offspring to be of the blue-barred *C. livia* color pattern, as we have regularly demonstrated in our experiments. In other words, the "reversion" to *C. livia* plumage is easy to obtain, but I do not know of any possible combination of domestic races that will produce a reversion to any other wild species that is today existent.

The fertility of the hybrids obtained from crossing *C. leuconota* with the domestic pigeon was another argument used by Ghigi for the polyphyletic origin of the latter. The hybrids gave no fertility inter se, but the male proved fertile when backcrossed to domestic pigeons. The females were infertile, as is ordinarily the case, in conformance with the general law formulated by Haldane (1922). Experiments at this laboratory have shown the possibility of transferring a genetic character from one species to another, but it is a proceeding which requires time and patience. It is relatively easy with a dominant monogenic character, but anyone who contemplates transferring a recessive character to another species will be well advised to give careful thought to his plans; and the possibility of transferring in toto such a character as a considerable size difference seems very remote and extremely unlikely ever to have been accomplished by pigeon fanciers who had no knowledge of genetics.

The interspecies transfer referred to above was of an intensity factor, *D*, of *Streptopelia chinensis,* which by hybridization and backcrossing has been incorporated in the domestic ringdove, *Streptopelia decaoto* (= *risoria*). The blond variety of ringdove has the gene d^b, and the white variety d^w. As a consequence, we now have a third variety of ringdove, "dark," previously unknown in domestication. This has now been carried through nine backcross generations and is fully fertile with other domestic ringdoves.

Another cross is of *Columba guinea* with the domestic pigeon. The pigeon used did not have the gene for check pattern and was therefore *cc.* The pattern of *C. guinea* shows a decided check, which appears to be due to the homologue of *c,* for among the descendants, down to the fourth backcross generation, we have checkered birds, obviously due to the gene *C,* introduced from *guinea.* These birds exhibit no other visible *guinea* characters, however, and are fully fertile. Since it is relatively easy to carry a simple dominant character over in this way, it is entirely

[2] A good colored illustration of *C. leuconota* may be found in Baker (1913), pl. 14.

possible that it may have been done by some enterprising pigeon breeder.

Immunogenetic studies by Irwin, Cole, and Gordon (1936) have shown that some of the numerous blood characters of *guinea* have been carried along in several of these birds to the fourth backcross generation ($\frac{1}{32}$ *guinea*). The extent to which they are retained depends on the genetic composition of the particular individuals that happen to be selected for breeding.

Crosses have been made also of *C. oenas* with the domestic pigeon and continued by backcrosses in the same way. The birds in later generations look like ordinary pigeons, showing no trait from *oenas*, and are fertile when mated inter se and with domestic pigeons.

Owing to the fact that he did not recover the *livia* type from crossing various domestic breeds, Ghigi assumes that domestic pigeons of the larger type do not trace back to *livia*, "but to a large insular species domesticated in antiquity," and now presumably extinct, since we can scarcely assume that it would still live and not have been discovered. Furthermore, if we are to look to hypothetical wild species for the origin of all those characters of domestic pigeons which are not present in *livia*, we shall have to assume that a bizarre lot of wild species have become extinct since the domestication of pigeons by man began. Darwin has marshaled the arguments against this supposition so thoroughly and they are still so cogent that there seems to be no necessity of going into them further. It seems safe to assume that characters cannot have come in from the wild widely different from those that are known in the wild species of today. We have already seen that the check pattern may conceivably have been brought in from such a species as *C. guinea*. It would appear from superficial appearance, but it is not shown by breeding tests, that some species of *Columba*, such as *C. janthina* of Japan, may carry the factor S, which spreads black pigment, and if so they might have been a possible source of the "spread" character which wild *livia* lacks.

So far as our knowledge of pigeon genes goes at present, these two are the only ones which might have been introduced by hybridization, and there are others, such as B^A, dominant red or gray, which are not found in any of the wild species. The same is true of numerous recessive characters, e.g., recessive red, factor e. These facts, together with the many characters of domestic birds which would have rendered their possessors incapable of existing under wild conditions and the difficulties of amalgamating characters by hybridization, make it improbable that this process has played any considerable part in producing the great variety of domestic breeds.

Finally, mutation is a process which appears entirely sufficient for furnishing the necessary materials for all the great diversity of colors, size, and form that are found. It is necessary only to call attention to the large number of varieties of the Budgerigar, as discussed, for example, by Steiner (1932) and Watmough [1935] which have been developed in a scant 100 years by fanciers, and then to remember that the pigeon has been domesticated at least 5,000 years, according to Darwin (p. 211). We know, furthermore, that mutations, which furnish the material for domestic varieties, frequently occur also in the wild. We do not know whether the conditions of domestication in any way stimulate their more frequent occurrence. Darwin refers occasionally to the Pallasian doctrine that "variability, or the appearance of new characters, is due to some mysterious effect from the crossing of two species, neither of which posssesses the characters in question" (p. 194). This idea probably arose by extension from the frequent appearance of new and unexpected characters and the subsequent increased variation resulting from complementary factors in different varieties, races, or breeds within the same species brought together by crossing. As a matter of fact, very little that is new or that might not be expected appears in interspecific hybrids among animals; the hybrid is ordinarily an intermediate or blend of the parents. As a consequence, hybrid birds taken in the wild, such as the frequent hybrid ducks shot by sportsmen, can be referred with a high degree of certainty to the species concerned. The high degree of sterility of the hybrids keeps the species from being swamped. Crossing within the species, on the other hand, when variability exists, is the means by which new combinations of traits that characterize new breeds are made.

CONCLUSIONS

Few of the characters distinguishing the widely various races of domestic pigeons and not possessed by *Columba livia* are found in any related wild species.

Such characters are known to arise commonly by mutation which, followed by subsequent interbreeding and selection, is sufficient to explain the origin of the multiplicity of breeds.

Certain characters may be transferred from one species to another by hybridization, and it is possible that certain minor characters may have been introduced into domestic pigeons in this way from species other than *livia*. Considering, however, the difficulties involved and the small number of characters available, it seems very unlikely that hybridization has played any considerable role in the origin of domestic pigeons.

SUMMARY

After studying carefully the evidences available to him, Darwin concluded that all the known varieties of domestic pigeons were descended from the wild rock pigeon, *Columba livia*. In recent years there have been suggestions that the domestic pigeons really have a polyphyletic origin and that much of the observed striking variability is a result of hybridization of two or

more species. Experimental studies indicate that although *C. livia* may hybridize within certain limits, so that a polyphyletic condition is possible, a careful study of the genetic characters involved makes it appear more probable that these have arisen as a result of mutations which have occurred "spontaneously" under domestication.

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EFFECT OF RESTRICTING THE CEREAL DIET OF PIGEONS TO CORN AND WHEAT[1]

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INTRODUCTION

The dietary needs of pigeons have been reported by several workers, including Sugiura and Benedict (*6*),[2] Emmett and Peacock (*2*), and Carter and O'Brien (*1*), with the general conclusions that pigeons require little if any vitamin A in their diet and no vitamin C, but that they must receive vitamin B_1. In addition, Carter and O'Brien (*1*), also observed the inadequacy of the protein of rice and the need for vitamin B_3 for normal-weight recovery in pigeons supplied with vitamin B_1 after loss of weight on a ration deficient in this respect. Pollard and Carr (*5*), in testing the nutritive values of cereal grains for egg production, fed pigeons on single-grain diets for 6 months, using barley, buckwheat, Canada peas, corn, hemp, kafir, oats, popcorn, rye, soybeans, sunflower seed, and wheat. They observed that squabs were reared to maturity on only the wheat and rye diets; that squabs were hatched from only the wheat, rye, corn, and oats diets; that broken eggs were noted constantly in the lot receiving soybeans, and no eggs were produced from the pairs fed popcorn, sunflower seed, or buckwheat; and that no eggs hatched from the birds fed barley, Canada peas, hemp, or kafir.

Lee and Hays (*3*) recommend that pigeons being kept for squab production receive a mixture of grains including yellow corn, kafir or milo, cowpeas or Canada peas, wheat, oat groats, and hempseed, but report no experimental data to confirm their recommendation.

In all the studies observed no data were presented showing the effect of maintaining pigeons for a year or longer on a simple diet restricted to two or three essential grains, and with that view in mind the present project was established.

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[1] Journal series paper of the New Jersey Agricultural Experiment Station, Department of Poultry Husbandry.

[2] Italicized numerals in parentheses refer to Literature Cited, p. 468.

MATERIALS AND METHODS

The experimental work was begun in conjunction with the operation of the New Jersey State Pigeon Breeding Contest at Millville, New Jersey. In the beginning, a mixture, by weight, of one-third whole yellow corn, one-third cracked yellow corn, and one-third hard red wheat was taken arbitrarily as a basic feed. Pedigreed White King stock being reared for general breeding work was used. The regular contest diet, consisting of 40 percent of whole yellow corn, 20 percent of kafir corn, 15 percent of red wheat, 15 percent of Canada peas, and $2\frac{1}{2}$ percent each of hempseed, millet, hulled oats, and buckwheat, with some slight seasonal variations, was used to rear the stock and maintain it for a portion of a year before any change was made in the experimental ration. The experimental feeding always began on October 1 and continued for 51 weeks to correspond with the fiscal year of the breeding contest. All pairs used had been producing squabs for 6 to 10 months before being placed in the experimental pens. The project was continued for 3 years, 4 pairs being used in 1935-36, 4 pairs in 1936-37, and 10 pairs in 1937-38, a total of 18 pairs. As a control for the restricted corn and wheat diet, an additional 11 pairs of mated pigeons of the same age and breed were fed a diet, during 1937-38, consisting of 85 percent of the whole corn, cracked corn, and wheat mixture and 15 percent of Canada field peas.

The birds were confined in small pens with an outside wire enclosure. Records were kept of the eggs laid, their fertility, hatchability, and the livability of squabs. Squab weights were taken when the youngsters were 28 days old. In assembling the data, all eggs and squabs in the nest at the end of the year were omitted from the records, as well as all eggs accidentally broken by the birds. This loss was practically identical in the various lots used and did not in any way influence the results obtained.

RESULTS AND DISCUSSION

Table 1 gives the comparative data on the two lots of birds. It will be observed that there was a significant difference in the number of eggs laid, the number of days between the first eggs of each egg-clutch period, and the individual squab weights, the birds receiving only corn and wheat producing fewer eggs, having a longer period between clutches, and smaller squabs than when Canada peas were used. The other factors observed, including fertility and hatchability of eggs, as well as livability of squabs, were not affected by restricting the ration to corn and wheat. The group that received the Canadian field peas gave a noticeably poorer fertility, but this condition was noted in the birds prior to being changed to the experimental ration and could not be attributed to the feed.

A comparison of the production records of the birds fed only corn and wheat with those previously published by the author (*4*) as a standard for the White King breed, also shows significant differences in the number of eggs laid and in the average weight of squabs produced, with no differences in fertility or hatchability of eggs or livability of squabs. Thus, further evidence is given that the deleterious effect of the corn and wheat diet arose from a retardation of the growth of the squabs and a decrease in the number of eggs produced, the latter apparently being brought about by a lengthening of the time between clutches.

To test further the possibility that restricting the diet to corn and wheat had the effect of lengthening the time between clutches, the records of all the pairs prior to being changed to the experimental feeds were summarized. The mean number of days between clutches for the 18 pairs changed to a corn and wheat diet was 38.89 ± 0.32 prior to the change, and 48.42 ± 0.82 after the change, a difference in means of 9.53 ± 0.88 days, which is highly significant. On the other hand, the mean number of days between clutches for the 11 pairs in the group fed corn, wheat, and Canada peas was 38.02 ± 0.32 before the change in feed and 41.21 ± 0.92 after the change, the difference in means being 3.19 ± 0.97 days, which is insignificant. Both groups were almost identical prior to the change, indicating a high uniformity in this respect, and emphasizing the notable change brought on by the restriction of the diet to corn and wheat only.

TABLE 1.—*Mean annual production per pair of White King pigeons receiving diets of corn and wheat and of corn, wheat, and Canada peas*

Item	Lot 1, on the corn and wheat diet	Lot 2, on the diet of corn, wheat, and Canada peas	$\frac{D}{P.E.}$
Total eggs, number	13.82±0.45	16.46±0.43	4.3
Total squabs, number	10.11± .41	10.90± .51	1.2
Fertility of eggs, percent	90.87±1.38	80.23±2.89	3.3
Hatchability of fertile eggs, percent	97.13± .80	96.37±1.60	.42
Livability of squabs, percent	92.39±1.91	94.48±1.01	.97
Total production (live weight), ounces	182.83±7.37	209.82±9.71	2.2
Average squab weight, ounces	18.22± .10	19.23± .15	5.6
Days between egg-clutch periods, number	48.42± .82	41.21± .92	5.9

Although the number of squabs and their total weight did not show significant differences in spite of greater egg production and heavier squabs when Canada peas were added to the diet, this apparent discrepancy is accounted for by the lowered fertility in the lot to which the peas were fed. If this factor had been constant in both lots, the effect, on total squab production and weight, of restricting the diet to corn and wheat would have been more pronounced. The important facts are that the feeding of corn and wheat alone increased the time between clutches, thus lowering the total possible number of squabs in a year, and reduced the squab weight, but did not affect fertility or hatchability of eggs or livability of squabs.

SUMMARY

Eighteen pairs of White King pigeons in their second year of production gave evidence that the feeding of a diet consisting of one-third whole yellow corn, one-third cracked yellow corn, and one-third hard red wheat had the effect of lengthening the time between clutches of eggs and reducing the weight of squabs in comparison with the results obtained from 11 pairs fed a mixture of 85 percent of the same feed and 15 percent of Canada field peas. Fertility of eggs, hatchability of fertile eggs, and livability of squabs were not affected by restricting the diet to corn and wheat in the proportions stated.

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FEED REQUIREMENTS OF RABBITS

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Rabbits are raised commercially in the United States chiefly for meat and pelts. The principal source of income is the sale of meat; consequently, first consideration is given to the rapid development and the proper conditioning of the rabbits for the market. When ready for the market the rabbits are slaughtered regardless of the primeness of the pelt, which is a byproduct of meat production.

On the American market are three classes of dressed domestic-rabbit meat: Broilers, fryers, and roasters. Broilers are young rabbits that weigh, when dressed, from $\frac{3}{4}$ to $1\frac{1}{2}$ pounds; fryers are young rabbits that weigh, when dressed, from $1\frac{1}{2}$ to 3 pounds; and dressed roasters weigh more than 3 pounds. In sections where the greatest quantity of rabbit meat is consumed, the heavier type of fryer-rabbit carcass, weighing about 2 to $2\frac{1}{4}$ pounds, is the most popular.

The commercial production of rabbits is a business of converting grains, green feed, and roughages into meat for human consumption. In this country, the relative cost of a pound of total digestible nutrient from concentrated feeds as compared with the cost of a pound of total digestible nutrient from roughages favors the use of considerable grain in developing and conditioning rabbits for the market. Incorporating the necessary quantity of concentrates in the ration promotes rapid development and early finish, and thereby shortens the feeding period and reduces the mortality hazard.

Rabbits are raised in every State in the Union. The kinds of feed crops raised in the different regions vary; consequently, there are a large number of feeds, both concentrates and roughages, available and adapted to rabbit production. The industry is interested in dependable information on the best methods of preparing these feeds and in making rations that are economical and that will produce a quality product. For 11 years the United States Rabbit Experiment Station, operated by the Bureau of Biological Survey at Fontana, California, has been carrying on experimental work to obtain definite information on these subjects. Several thousand rabbits of five generations have been used in these studies. Only one breed, the New Zealand White, has been used, in order to eliminate the variables that would occur if more than one breed were used. The problems studied were of a general character; the data obtained, therefore, are applicable to other breeds.

The rabbits consisted of mature bucks averaging 10 to $10\frac{1}{2}$ pounds in weight, mature does averaging 10 to 12 pounds, bucks and does ready for breeding at 6 months of age and averaging $9\frac{1}{2}$ and 10 pounds in weight, respectively, and young rabbits weaned at 56 days of age and averaging about 4 pounds.

The station devised a self-feeder—a feed hopper with separate compartments for the different types of concentrates—that proved to be exceptionally valuable. Through its use a variety of concentrated feeds could be kept before the rabbits constantly, the natural scratching habit of the rabbit overcome, and waste and contamination of feed prevented. This self-feeder made possible a study of the palatability of feeds, the proper proportion of concentrates to roughages, and the optimum nutritive ratios for growth and production. The rabbits showed remarkable ability in selecting and balancing their own rations when allowed free choice from an adequate variety of feeds. At the beginning of the investigation, the common feeds of rabbits, in various forms and combinations, were offered the animals being studied to determine the proper methods of preparing the feeds and the number of feeds necessary for maintenance and production.

GRAINS

Rabbits of all ages, from the time they came out of the nest box at about 3 weeks of age to maturity, showed a preference for the whole cereal grains—oats, wheat, the grain sorghums, and barley—and demonstrated a dislike for finely ground feeds. Grains that were ground, rolled, or pelleted, and then stored, especially during the warm season, depreciated in palatability and feeding value, and it actually required more pounds of the milled products than of the grains in their natural form, to produce a unit of gain in live weight.

Self-fed rabbits, or those that had free access to various feeds at all times, ate wheat bran only to the extent of $2\frac{1}{2}$ percent of the total concentrates in their ration. No advantage was derived from including so small a proportion of wheat bran.

Shelled corn (maize) was not so palatable as the other grains. The self-fed rabbits ignored the flinty type of corn that is raised in the Southeastern and in the Western States. The softer corn raised in the Central States was consumed if the concentrate part of the ration was sufficiently restricted to force the rabbits to eat the corn.

There was considerable variation in the palatability of the grains. Generally, the rabbits selected the grains in the order of whole oats, whole wheat, the whole grain sorghums, and whole barley. There was some individual variation in the choice of grains, some rabbits preferring wheat to oats. There seemed to be little difference in the palatability of the grain sorghums, but the rabbits usually ate them in the order of milo, hegari, feterita, sagrain, and kafir.

The quality of the grain and the length of time it had been stored were important factors. Although oats were the first choice, young rabbits, especially those just out of the nest box, refused oats with little, if any, kernel, if they had access to other feeds. Grains that had been stored for a long time were less palatable. Normally, the grain sorghums proved to be more palatable than barley, but when barley from a new crop was offered with milo that had been in storage for a year, the rabbits selected the barley.

PROTEIN SUPPLEMENTS

A ration composed of grains, legume hays, and green feed or root crops was not entirely satisfactory as it was deficient in protein. Supplementary protein was furnished by adding soybean meal, peanut meal, sesame meal, or linseed meal, or the pea-size oil cake or the pelleted form of these meals. The pea-size oil cake or the pelleted form of these proteins was found to be desirable for mixing with grains. Pellets three-sixteenths inch in diameter and one-eighth inch long proved to be the most satisfactory size.

The meal form of the proteins was unpalatable. When it was necessary to add the meal to the ration to supply the required protein, at least half the grain used in the concentrate mixture had to be rolled in order that the meal would adhere to the grains. The mixture was dampened slightly just previous to feeding to prevent the meal from settling out and being wasted.

LEGUME HAYS

Legume hays—alfalfa, clover, sweetclover, lespedeza, cowpea, vetch, kudzu, soybean, and peanut—all proved to be palatable and adapted to the feeding of rabbits. Hays for rabbits should be well-cured, fine-stemmed, green in color, leafy, and free from mildew or mold. When hay was fed whole, much was wasted because the rabbits would pull a stem out of the hay manger, eat a part of it, and drop the rest. This wastage was avoided and the hay put into a more convenient form for feeding by cutting it into 3- to 4-inch lengths.

GREEN FEEDS AND ROOT CROPS

Green feeds—immature and actively growing plants—are rich in protein, minerals, and vitamins, especially vitamin A. They are soft and tender and consequently are easily digested. These crops are the natural food of rabbits and are desirable in a ration for maintaining health and vitality. When green feed is not available, root crops may be used to supplement the hay-grain ration.

The rabbits consumed a variety of green feeds, including lawn clippings, rape, cabbage, kale, palatable weeds, waste from garden vegetables, small prunings from trees, green-growing cereal crops, green legume crops, and sweetpotato vines.

Root crops may be fed fresh or may be stored for winter use. Carrots, sweetpotatoes, beets, mangels, and turnips are palatable and useful for feeding rabbits.

VITAMINS

Little definite information is available concerning the vitamin requirements of rabbits. Unquestionably, a vitamin deficiency is less likely if the animals are supplied with a wide variety of feeds, including two or more grains, a plant-protein supplement, good-quality legume hay, and green feed or root crops. It is especially important that the legume hay be bright green in color and leafy, and that the green feeds or root crops be fresh and sound.

SALT

Rabbits require more salt (sodium chloride) than the quantity normally present in the grain and roughage portions of their ration. In tests to determine the annual salt requirements of rabbits, it was found that these animals would voluntarily consume in a year a quantity of salt averaging 0.88 percent of their live weight. The records showed a marked difference in the quantities taken by individual rabbits, as well as a variation in the quantities eaten by the same individual at different times. This fact suggests that there may be a distinct advantage in self-feeding salt or in keeping a block of salt at all times in the hutch so that each animal may have opportunity to satisfy its needs from day to day.

In large rabbitries, however, it would be troublesome to keep blocks of salt available at all times in all the hutches. It is, therefore, much more convenient to mix the salt with the ration. In mash feeds or pelleted rations it is easy to incorporate the necessary quantity of salt. In whole-grain rations it is advisable to put the plant-protein meal into the pellet form, and in doing this the necessary quantity of salt can be added previous to pelleting. From the data obtained from the tests, it was determined that one-sixth pound of salt added to each 100 pounds of concentrates will supply the salt requirements of the rabbits.

MINERALS

Concerning the mineral requirements of rabbits little dependable information is available. In the studies carried on at the United States Rabbit Experiment Station, in which several thousand rabbits of five generations were fed rations composed of two or more cereal grains, a plant-protein supplement, good-quality alfalfa hay, green feed, and salt (sodium chloride), no mineral deficiencies have been noted.

WATER

Rabbits should be supplied with plenty of fresh, pure water. In the summer they require large quantities. A 10- to 12-pound doe and her 8-week-old litter of seven will drink about a gallon of water in 24 hours.

NUTRITIVE RATIO

The quantity of proteins eaten by the rabbits varied considerably, depending on the age of the animals and the type of production. The quantity consumed by does and litters being self-fed increased materially when the litters came out of the nest box and began to eat. For a week or 10 days they ate as much (in some cases more) of the protein supplement as of all the other concentrates combined. The nutritive ratio during this period was narrow, averaging about 1:2. As the young developed, the quantity of protein consumed gradually decreased and the eating of carbonaceous feeds increased. The protein requirements for maintaining mature rabbits remained constant.

For practical feeding purposes, it would be impossible to have enough concentrated mixtures available in the rabbitry to provide for the changing protein requirements of the growing animals and the animals being maintained or in production. It was determined that at least two concentrate mixtures with nutritive ratios within limited ranges were desirable and economical for feeding the entire herd. Rations with a nutritive ratio ranging from 1:3.75 to 1:5 proved to be satisfactory for dry does, herd bucks, and developing does and bucks. Narrower nutritive ratios ranging from 1:2.75 to 1:4.5 were satisfactory for does and litters.

CHOICE AND NUMBER OF FEEDS TO USE IN RATIONS

The cereal grains are similar in nutritive value, and these feeds can be used in the ration interchangeably pound for pound without materially altering the nutritive value of the feeds. At least two kinds of grain and one of the plant-protein supplements are desirable for feeding with a legume hay, green feed, and salt, although the addition of one or two other kinds of grain will give variety. The choice of grains, plant-protein supplements, legume hay, and green feeds will be determined very largely by the availability of the feeds in a given locality and the relative cost of the different kinds.

QUANTITY OF FEED AND FREQUENCY OF FEEDING

Dry does, herd bucks, and developing does and bucks should be fed once a day all of a concentrate mixture that they will eat readily within 20 to 30 minutes after feeding. This quantity will be about $2\frac{1}{2}$ ounces a day. Does and nursing litters should be given, each 24 hours, all the concentrates they will consume without waste, the quantity to be regulated to meet the requirements of the individual or group.

Rabbits that are being conditioned for the market and does and litters may be full-fed (hand-fed or self-fed). They will eat about 2 parts of concentrates, by weight, to 1 part of legume hay. When the litters are weaned, the quantity of grain mixture fed to the dry does should be regulated by their physical condition. A good quality of legume hay should be kept before the rabbits at all times.

Green feed or root crops should be fed sparingly to rabbits that have not been accustomed to that kind of feed. One-tenth of a pound daily is sufficient for a doe or buck at first, and if such material is available and economical, the quantity may be gradually increased to what the rabbits will consume readily each day without waste. These feeds are bulky and should be used to supplement the grain-hay part of the ration and not to replace it entirely, except under some conditions to maintain mature rabbits not in production.

SUMMARY

Rabbits are raised commercially in the United States chiefly for meat and pelts. The principal source of income is the sale of meat, and the pelt

is a byproduct. The commercial production of rabbits is a business of converting grains, green feed, and roughages into meat for human consumption. The relative cost of nutrients from concentrated feeds compared with that from roughages favors the use of considerable grain in rations for market rabbits.

Experimental work conducted at the United States Rabbit Experiment Station at Fontana, California, in which several thousand rabbits of five generations have been used, has given definite information on the best methods of preparing feeds and of compounding rations for rabbits. A self-feeder devised at the station has proved to be exceptionally valuable in these studies. Rabbits of all ages, from the time they began to eat at about 3 weeks of age to maturity, showed a preference for whole grains and a dislike for finely ground feeds. The factor of palatability proved to be important in the feeding of rabbits. The rabbits selected the grains in the order of whole oats, whole wheat, whole grain sorghums, and whole barley. Shelled corn was practically ignored. Plant-protein supplements are desirable for properly balancing a grain-hay ration. Peanut meal, soybean meal, sesame meal, and linseed meal, or the pea-size oil cake or pelleted forms of these meals, are suitable for this purpose.

Legume hays—alfalfa, clover, sweetclover, lespedeza, cowpea, vetch, kudzu, soybean, and peanut—all proved to be palatable and adapted to the feeding of rabbits. The hay should be cut into 3- to 4-inch lengths to prevent waste in feeding.

Green feeds—lawn clippings, rape, cabbage, kale, palatable weeds, waste from garden vegetables, small prunings from trees, green-growing cereal crops, green legume crops, and sweetpotato vines —were found to be useful feeds in the ration. Root crops may be fed fresh or stored for future use. Carrots, sweetpotatoes, beets, mangels, and turnips may be used to supplement the ration.

Little definite information is available concerning vitamin and mineral requirements of rabbits. A vitamin deficiency is less likely if the animals are supplied with a wide variety of feeds, including two or more grains, a plant-protein supplement, good-quality legume hay, green feed or root crops, and salt. Such a ration has not given any indication of mineral deficiency with five generations of rabbits used in feeding tests.

Salt in greater quantity than that normally present in the ration is required. The rabbits studied consumed in 12 months a quantity of salt equal to 0.88 percent of their live weight.

Nutritive ratios ranging from 1:3.75 to 1:5 were satisfactory for dry does, herd bucks, and developing animals. Ratios ranging from 1:2.75 to 1:4.5 were desirable for does and litters.

At least two kinds of grain and one plant-protein supplement are desirable for feeding with a legume hay, greed feed, and salt, although the addition of one or two other kinds of grain gives variety.

Breeding and developing does and bucks of the medium-weight breeds can be maintained by feeding a daily ration composed of $2\frac{1}{2}$ ounces of a good concentrate mixture, self-fed legume hay, and one-tenth pound of green feed.

Animals being conditioned for the market and does and litters may be full-fed (hand-fed or self-fed).

DIE AUSNUTZUNG EINIGER FUTTERMITTEL DURCH DAS KANINCHEN

Von OBERASSISTENT DR. AGR. HABIL. HANS BRÜGGEMANN, *Versuchs- und Forschungs-Anstalt für Tierzucht, Kraftborn-Breslau, Deutschland*

Die Durchsicht des über das Nutztier Kaninchen vorliegenden umfangreichen Schrifttums läßt erkennen, daß das Kaninchen in vieler Hinsicht das Interesse der Wissenschaft als Versuchsobjekt gefunden hat. Rassenbiologische als auch genetische Studien liegen in vielerlei Richtungen vor, wie auch Haltungs- und Nutzungsfragen weitgehende Bearbeitung gefunden haben. Weiterhin diente das Kaninchen als Versuchsobjekt für physiologische Untersuchungen, während das Sondergebiet der Ernährungsphysiologie in nur sehr wenigen Fällen bearbeitet worden ift. Es mag an der betriebswirtschaftlichen Stellung des Kaninchens als Abfallverwerter der Haus- und Gartenwirtschaft liegen, daß die Frage der Futterausnutzung in so wenigen Fällen in den wissenschaftlichen Betrachtungskreis einbezogen worden ist. Es liegt aber neuderdings unbedingt das Bedürfnis vor, das Wissen über diesen Fragenkomplex zu erweitern, da die Entwicklung der letzten Jahre dazu führte, daß dem Kaninchen eine steigende wirtschaftliche Bedeutung zugesprochen werden muß. Dor allen Dingen gilt es, den Mangel an Ausnutzungsversuchen an Kaninchen mit den verschiedenen gebräuchlichen Futtermitteln zu beheben, um dem Zustand ein Ende zu bereiten, daß Verdauungswerte, die am Schwein und Hammel gefunden wurden, auf das Kaninchen wegen Fehlens arteigener Untersuchungen übertragen werden müssen.

Es muß festgestellt werden, daß mit den bis heute vorhandenen Kenntnissen es nicht möglich erscheint, Futterrationen für Kaninchen in gleicher Art wie bei anderen Nutztieren zusammenzustellen. Um diese Lücke schließen zu helfen, wurden Ausnutzungsversuche an Kaninchen mit den für die Kaninchenfütterung gebräuchlichsten Futtermitteln durchgeführt.

Die Versuchsanordnung wurde so gewählt daß dem eigentlichen Versuch ein Vorversuch vorgeschaltet wurde, der jeweils 7 Tage dauerte und dazu diente, das Tier auf das Versuchsfutter einzustellen. Der Hauptversuch dauerte im allgemeinen 10 Tage, in einigen Versuchen wurde er sogar auf 15 Tage ausgedehnt, um genügende Mengen Kot für die Analyse zu gewinnen. Der tägliche Kotanfall dieser Hauptperiode wurde gesammelt, seine Menge festgestellt, mit einigen Tropfen Formaldehyd konserviert und zur Analyse aufbewahrt. Futtermittel und Kot wurden nach den für die Landw. Versuchsstationen verbindlichen Untersuchungsmethoden geprüft.

Die Schwierigkeiten, die Ausnutzungsversuche mit Kaninchen bereiten durch die Eigenart dieses Versuchstieres, das Futter nicht quantitativ aufzunehmen, und vor allem die Neigung zur Koprophagie wurden durch die Konstruktion eines Spezialkäfigs beseitigt.

Die Versuche wurden mit ausgewachsenen Kaninchen der blauen Wiener Rasse durchgeführt. Im allgemeinen wurde die Prüfung eines Futtermittels mit 3 Tieren vorgenommen. In Einzelfällen mußte das eine oder andere Tier von der Berichterstattung ausgeschlossen werden, weil irgendwelche Störungen während des Versuches das Versuchsergebnis beeinflußt hatten.

Zur Durchführung der Ausnutzungsversuche ift noch zu sagen, daß, soweit es möglich erschien, die Versuche ausschließlich mit dem Versuchsfutter durchgeführt wurden. Da aber das Kaninchen einen gewissen Rohfasergehalt im Futter benötigt, sind die rohfaserarmen Futtermittel nur in Verbindung mit rohfaserreichen in die Prüfung zu nehmen. Die notwendige Ergänzung wurde in allen Fällen durch das eingangs geprüfte Wiesenheu geschaffen. So betrug die tägliche Futterration beispielsweise beim Ausnutzungsversuch mit gedämpften Kartoffeln 200 g gedämpfte Kartoffeln + 60 g Wiesenheu. Unter Zugrundelegung der ermittelten VC (Verdauungskoeffizienten) beim Wiesenheu sind im Differenzverfahren die VC des in Prüfung stehenden Futtermittels errechnet worden.

Die ermittelten Verdauungskoeffizienten werden in folgender Aufstellung mitgeteilt:

Tabelle 1

Futterart	Organ. Substanz	Rohprotein	Reineiweiss	Rohfett	Rohfaser	N-freie Extr.-St.
1. Wiesenheu	47,2	60,1	63,5	43,1	18,5	64,5
2. Luzerneheu	61,3	75,7	73,7	15,9	38,6	72,6
3. Brennesselheu	63,0	95,6	89,9	31,6	42,4	78,9
4. Grüne Luzerne	81,5	89,1	86,8	70,8	66,0	88,0
5. Grüne Süßlupine	78,9	91,1	90,2	73,2	56,5	84,1
6. Maisgärfutter	55,0	79,4	37,5	96,1	24,2	68,8
7. Hafer	63,8	79,0	78,6	90,3	18,0	72,2
8. Gerste	89,6	78,0	80,2	90,2	72,2	93,3
9. Weizen	94,0	81,0	80,5	91,8	90,5	97,0
10. Futterrüben	96,6	66,4	36,3	......	100,0	95,7
11. Ged. Kartoffeln	98,3	58,3	54,4	100,0	100,0	99,1

Die Zusammenstellung läßt erkennen, daß das Kaninchen als schlechter Rohfaserverwerter anzusprechen ist, eine Eigenart, die besonders bei den rohfaserreichen Futtermitteln in die Erscheinung tritt. Das gleiche Wiesenheu, das hier beim Kaninchen geprüft wurde, unterlag derselben Prüfung beim Wiederkäuer (Schaf). Die am Schaf ermittelten VC stellten sich vergleichsweise wie folgt:

Tabelle 2

	Ermittelte V.C.	
	Kaninchen	Wiederkäuer
Rohprotein	60,1	60,1
Reineiweiß	63,5	59,0
Rohfett	43,1	32,0
Rohfaser	18,5	72,4
N-freie Extraktstoffe	64,5	75,6

Aus diesen Angaben ist ohne weiteres die Überlegenheit des Wiederkäuers gegenüber dem Kaninchen in der Rohfaserausnutzung zu ersehen.

Um die ermittelten VC für die praktische Kaninchenfütterung nutzbar zu machen, wurde eine Auswertung der Analysenwerte der einzelnen Futtermittel unter Zuhilfenahme dieser VC vorgenommen.

Das Ergebnis wird in folgender Aufstellung verfolgt:

Tabelle 3
[In 100 g sind enthalten in g:]

	In der Trokkensubstanz		In der frischen Substanz	
	verdaul. Eiweiss	Gesamtnährstoffe	verdaul. Eiweiss	Gesamtnährstoffe
Wiesenheu	6,1	46	5,2	39,1
Luzerneheu	19,5	57	16,6	48,5
Brennesselheu	24,5	61	20,8	51,9
Grüne Luzerne	27,9	79	5,6	15,8
Grüne Süßlupine	27,7	74	3,3	8,9
Maisgärfutter	5,2	53	1,3	12,7
Hafer	11,8	66	10,3	57,1
Gerste	11,2	89	9,7	77,2
Weizen	11,5	95	10,9	82,2
Futterrüben	2,4	91	0,3	10,9
Ged. Kartoffeln	5,3	91	1,3	22,0

Mit diesem auf dem Wege von Analysen und Ausnutzungsversuchen neu ermittelten Werten ist die Grundlage exakter Fütterung unserer Kaninchenbestände unbedingt erweitert worden, denn wenn das Kaninchen überhaupt nach wissenschaftlichen Grundsätzen ernährt werden soll, müssen arteigene Untersuchungen diesen Berechnungen zugrunde gelegt werden.

ZUSAMMENFASSUNG

Das Fehlen von Ausnutzungsversuchen am Kaninchen war Veranlassung zur Durchführung von Ausnutzungsversuchen mit verschiedenen

gebräuchlichen Futtermitteln bei diesem hauswirtschaftlichen Nutztier. Es wurde die Verdaulichkeit von Wiesenheu, Luzerneheu, Brennesselheu, grüner Luzerne, grüner Süßlupine, Maisgärfutter, haferkörner, Gerstenkörner, Weizenkörner, Futterrüben und gedämpften Kartoffeln festgestellt. Die ermittelten Verdauungskoeffizienten werden mitgeteilt. Die praktische Auswertung dieser Ermittlungen fand in einer diese Futtermittel erfassenden Aufstellung ihren Niederschlag, in der für jedes Futtermittel dessen Gehalt an verdaul. Eiweiß und Gesamtnährstoffen niedergelegt wurde. Der Kaninchenzüchter erhält hierdurch einen Maßstab für die Bewertung einer großen Anzahl Futtermittel für die Kaninchenernährung auf Grund arteigener Untersuchungen. Bis heute wurden die am Wiederkäuer und Schwein ermittelten VC auf das Kaninchen übertragen.

SUMMARY

The lack of utilization experiments with rabbits led to investigations as to the utilization, by rabbits, of commonly used foodstuffs. Digestion coefficients were established for meadow hay, lucerne hay, hay of stinging nettles, green lucerne, green sweet lupine, ensilaged maize, oats, barley, wheat, beet roots, and steamed potatoes. The established digestion coefficients are reported. The practical results of these experiments are given in a table showing the content and total amount of nutritive substance of each of the above-named feedstuffs. Through these experiments with rabbits, rabbit breeders have a means of judging the value of a great number of feedstuffs for these animals. Up to the present time, the digestion coefficients established for ruminants and pigs had to be applied to rabbits.

DIE GRUNDZÜGE DER KANINCHENFÜTTERUNG IN DEUTSCHLAND

Von Dr. R. Fangauf, *Versuchs- und Lehraushalt für Geflügelzucht, Kiel-Steenbek, Deutschland*

A. DIE FUTTERGRUNDLAGE

Will man die in Deutschland für die Kaninchenfütterung aufgestellten Richtlinien recht verstehen, do muß man davon ausgehen, daß der eigentliche Zweck unserer Kaninchenhaltung nicht in der Gewinnung von Fleisch, Fellen und Wolle besteht, sondern daß sie auf die Ausnutzung von Leistungsreserven abzielt, daß sie mit andern Worten dazu dient, Abfallstoffe zu verwerten, die bisher in den Mülleimer oder auf den Komposthaufen im Garten gelangten. Die wirtschaftliche Kaninchenhaltung wird daher in Deutschland nicht farmmäßig, sondern nur im Kleinen als Nebenbeschäftigung betrieben und hat nur dort ein Daseinsrecht, wo Abfallstoffe vorhanden sind; bei überwiegendem Futterzukauf ist sie als eine sportliche Betätigung zu bezeichnen.

Futterstoffe, die durch keine andere Tierart und auf keine andere Weise verwertet werden, liefert die Küche in Form von Kartoffelschalen, Brotresten, Obst- und Gemüseabfällen und der Garten in Form der Unkräuter und der Gemüseblätter, welche bei der Ernte anfallen. Während es einerseits diese Abfälle sind, welche die Futter Grundlage des Kanichenhalters bilden, besteht sie andererseits aus den Wildpflanzen, aus denen sich der Mischwuchs der Wege und Grabenränder, der Eisenbahn- und Kanalböschungen, sowie des Ödgeländes (Baugelände, Lagerplätze der Fabriken, Schuttabladen u. dergl.) zusammensetzt. Aus diesem Grunde wurden Untersuchungen über die Verwendbarkeit der häufigsten Unkräuter als Kaninchenfutter durchgeführt, aus welchen sich ergab, in welcher Form die einzelnen Pflanzen am geeignetsten zur Verfütterung gelangen (in frischem Zustand, als Heu oder eingesäuert).

Die in Deutschland vorherrschenden klimatischen Verhältnisse machen die Bereitstellung eines sehr großen Vorrates für die Winterfütterung notwendig. Jn den vier Monaten üppigen Wachstums darf nicht nur das täglich notwendige Futter gesammelt, sondern es muß darüber hinaus das gesamte Winterfutter eingebracht und haltbar gemacht werden. Die Sicherung des Winterfutters ist daher eine notwendige Voraussetzung der Kaninchenhaltung und wir haben der Technik der Konservierung besondere Aufmerksamkeit gewidmet. Jhre Grundlagen bestehen in folgendem:

1. *Die Gewinnung eines nährstoffreichen Heues.*—Diese ist nur möglich durch Benutzung geeigneter Trockengerüste. Sie schützen die Grünmasse vor Regenfeuchtigkeit, vor zu starker Sonnenbestrahlung und sie vermeiden Bröckelverluste, welche durch mehrmaliges Wenden auftreten würden. Da es sich bei den in Betracht kommenden Unkräutern überwiegend um dickstengelige Pflanzen handelt, verläuft der Trocknungsprozeß nicht so schnell wie bei Gras, wodurch die Gefahr des Auftretens von Schimmel erhöht ist. Durch die Herstellung besonderer Trockengerüste konnte aber die Gewinnung hochwertigen Heues aus jeglichen Unkräutern gesichert werden.

2. *Die Herstellung von einwandfreiem Sauerfutter.*—Bei der Durchführung von Fütterungsversuchen konnte festgestellt werden, daß Sauerfutter von Kaninchen gern gefressen wird, und zwar wurde der tägliche Verzehr mit 200 g bis 400 g bei den verschiedenen Pflanzen ermittelt. Diese Erfahrung ist um so bedeutsamer, als im Herbst jeweils bei der Kohl- und Rübenernte eine so große Menge von Kohlblättern und Rübenköpfen anfällt, daß diese nicht in frischem Zustand verfüttert werden können, und als die Einsäuerung

überhaupt die einzige Möglichkeit der Haltbarmachung von dickfleischigen Blättern bietet. Sie erfolgt in Teer- und Benzinfässern. Die Unkräuter, Futterpflanzen und Gemüseabfälle werden möglichst gut zerkleinert und ohne Zusätze eingestampft. Auch eingesäuerte Kartoffeln werden von Kaninchen gern gefressen.

3. *Das Einlagern von Wurzelfrüchten.*—Hierfür kommen hauptsächlich Steckrüben, Futtermöhren, Kartoffeln und die Stengel von Markstammkohl in Betracht. Die Technik der Einlagerung nimmt Rücksicht auf die Eigenart der einzelnen Pflanzen hinsichtlich ihrer Kälteempfindlichkeit.

Mit Hilfe dieser drei Verfahren vermag der Kaninchenhalter seinen Bedarf an Winterfutter zu sichern. Stets kommt es darauf an, die Nährstoffverluste durch eine Vervollkommnung in der Technik der Haltbarmachung auf ein Mindestmaß zu beschränken.

chenabfälle, und diese Art der Fütterung ergibt durchaus befriedigende Leistungen sowohl was die Gewichtszunahme als auch die Wollmenge und Fellgüte betrifft. Bei Züchtern, welche etwas größere Bestände halten, ist jedoch bei reichlich vorhandenem Grünfutter die auf das einzelne Tier entfallende Menge an Küchenabfällen so gering, daß hier Futtermittel zugekauft werden müssen. Hält sich die Anwendung dieser Kraftfuttergaben in angemessenen Grenzen, so ist sie infolge der hierdurch erzielten höheren Ausnutzung der übrigen Nährstoffe und durch den Gewinn an Fleisch, Fellen und Wolle an sich gerechtfertigt. Für bestimmte Leistungen, wie z.B. bei säugenden Häsinnen können wir wahrscheinlich auf gewisse Kraftfuttergaben nicht verzichten. Es ist dagegen abzulehnen, sie zu dem Zweck zu verfüttern, bei manchen Rassen bestimmte Riesengewichte zu erzielen.

TABELLE 1.—*Futterverzehr*

(Täglicher Verzehr an Kraftfutter (A)*, Saftfutter (B)† und Heu (C) in Gramm.)

Rasse	Lebensmonat							
	3. (Juni)	4. (Juli)	5. (Aug.)	6. (Sept.)	7. (Okt.)	8. (Nov.)	9. (Dez.)	10. (Jan.)
	A B C	A B C	A B C	A B C	A B C	A B C	A B C	A B C
Hermelin	8/113/2	14/134/–	15/240/–	16/310/–	16/316/23	16/298/24	16/269/26	16/296/29
Russen	12/163/3	18/282/–	24/316/–	24/344/–	24/304/23	24/336/29	24/325/43	24/344/42
Gelbsilber	10/181/–	15/321/–	20/321/–	20/385/–	20/351/19	20/394/24	20/386/31	20/387/31
Angora	18/260/–	27/424/–	35/449/–	36/535/–	36/555/42	36/557/22	36/585/47	36/560/40
W. Wiener	18/250/3	27/471/–	36/570/–	36/608/–	36/640/–	36/576/44	36/590/57	36/594/59
Bl. Wiener	22/329/–	33/565/–	44/587/–	44/638/–	44/683/51	44/659/45	44/639/66	44/629/60
Frz. Silber	21/342/1	31/510/–	42/488/–	43/572/–	43/650/16	42/661/41	44/636/38	43/632/34
Dtsch. Widder	30/432/–	46/628/–	60/604/–	60/645/–	60/781/62	60/691/46	60/691/44	60/659/35
Dtsch. Riesen	31/332/5	30/613/–	70/681/–	70/730/–	70/827/40	67/938/33+	70/923/48	66/892/58

* 1/2 Hafer + 1/2 Kartoffelflocken.

† Wiesengras, Markstammkohl, Steckrüben u. dergl.

B. FUTTERMITTEL UND FUTTERMENGEN

Die Aufstellung einer genauen Futteranweisung, welche für alle Züchter die zweckmäßigste ist, läßt sich nicht ermöglichen, weil

a) das Freifutter bei jedem einzelnen Züchter anders ist, insbesondere fällt der Anteil der Küchenabfälle am Gesamtfutter verschieden hoch aus,
b) die Unterschiede der Jahreszeiten eine verschiedenartige Fütterung erfordern,
c) der Nutzungszweck in der Kaninchenhaltung (Gewinnung von Fleisch oder von Wolle) verschieden ist,
d) die zwischen den einzelnen Rassen bestehenden Unterschiede hinsichtlich ihrer Größe entsprechende Abweichungen in den Futtermengen erfordern,
e) bei der Haltung ganz kleiner Tierbestände nach anderen Richtlinien gefüttert wird, als in größeren Zuchten.

Aber es wird stets ein Grundfutter gereicht werden müssen, welches aus Rauhfutter und Saftfutter besteht und das auf die obengeschilderte Weise gewonnen und haltbar gemacht werden kann. Außerdem bekommen die Tiere Küchenabfälle ...

Durch Vergleichsversuche bei Angora konnte festgestellt werden, daß Eiweißfuttermittel keine spezifische Wirkung auf das Wollwachstum haben und durch die gleiche Menge Getreide oder andere Kohlehydratfuttermittel ersetzt werden können. Diese Feststellung kommt den deutschen Verhältnissen in sofern sehr zu statten, als Eiweißstoffe und Getreide für wichtigere Zwecke benötigt werden, während Hackfruchterzeugnisse im Überfluß zur Verfügung stehen. Bei denjenigen Züchtern, welche aus Mangel an Küchenabfällen Kraftfutter zukaufen müssen, besteht dieses daher aus Kartoffelflocken oder Zuckerschnitzeln.

Über die Höhe der Kraftfuttergabe wurden mit gestaffelten Haferrationen Untersuchungen bei Angora angestellt, bei welchen sich zeigte, daß sich eine Erhöhung über 40 g hinaus nicht mehr in gesteigertem Wollertrag auswirkt. Seitdem erhalten Angora 40 g Kraftfutter, welches gegenwärtig aus 20 g Kartoffelflocken + 20 g Zuckerschnitzel besteht. Da die in 40 g Hafer enthaltene Nährstoffmenge bereits durch ein Gemisch von 15 g Kartoffelflocken + 15 g Zuckerschnitzel gedeckt wird, halten wir eine Herabsetzung des obengenannten Kraftfuttergemisches auf 30 g ohne Einfluß auf den Wollertrag für möglich. Bei den Normalhaarrassen schwanken die Kraftfuttermengen von 20 g bei Zwergrassen bis zu 60 g bei Riesenrassen.

Da bisher keine Unterlagen über den Verzehr der Jungtiere während des Wachstums vorlagen, wurde dieser bei neun verschiedenen Rassen vom 8 Wochen Alter an für die folgenden 8 Monate ermittelt. Die mit zunehmendem Alter sich steigernden Verzehrszahlen sind in Tabelle 1 mitgeteilt. Wenn man unter Heranziehung der gleichfalls festgestellten Gewichtszunahmen (Tabelle 2) den Nährstoffverbrauch je 100 g Gewichtszunahme (die sogenannte Verwertungszahl) errechnet, so ergibt sich für die praktische Kaninchenhaltung die zwingende Forderung, daß Zwergrassen mit 5 Monaten, Mittelrassen mit 6 Monaten und Riesenrassen mit 7 Monaten geschlachtet werden müssen, weil die Zuanhmen von diesen Altersstufen an so niedrig werden, daß sie eine Fortsetzung der Fütterung nicht rechtfertigen.

TABELLE 2.—*Körpergewicht und Gewichtszunahme*
(Jn Gramm)

Rasse	Lebensmonat								
	2.	3.	4.	5.	6.	7.	8.	9.	10.
Hermelin	430	630	750	900	950	1080	1140	1160	1200
Zunahme		200	120	150	50	130	60	20	40
Russen	620	950	1310	1550	1725	1785	1950	2050	2100
Zunahme		330	360	240	175	60	165	100	50
Gelbsilber	750	1080	1430	1780	1850	2050	2230	2180	2170
Zunahme		330	350	350	70	200	180	−50	−10
Angora	980	1350	1900	2160	2350	2600	2830	2830	2620
Zunahme		370	550	260	190	250	310	5	−210
W. Wiener	1150	1750	2070	2550	2800	2950	3100	3280	3330
Zunahme		600	320	480	300	150	150	180	50
Bl. Wiener	1180	1780	2440	2935	3330	3480	3730	395C	4000
Zunahme		600	660	490	400	150	250	220	50
Frz. Silber	1320	1970	2400	2870	3150	3650	3770	3850	3950
Zunahme		650	430	470	280	500	120	80	100
Dtsch. Widder	1450	2180	2940	3450	3730	3980	4270	4300	4330
Zunahme		730	760	510	280	250	290	30	30
Dtsch. Riesen	1870	2370	3310	3850	4310	4920	5130	5450	5470
Zunahme		500	940	540	460	610	210	320	20

Die Ermittlungen von H. Brüggemann über den Wasserbedarf der Kaninchen sind in sofern sehr aufschlußreich, als in der Praxis auch hierüber grundverschiedene Ansichten vertreten werden und die meisten Kaninchenhalter ihren Tieren garkein Trinkwasser geben, sondern sich auf den Wassergehalt des Saftfutters verlassen. Der durchschnittliche Wasserbedarf des Kaninchens wird mit 180 g je Tag angegeben. Bei reichlicher Grünfütterung ist er hierdurch gedeckt, wogegen bei stärkeren Rauhfuttergaben die zusätzliche Aufnahme von Trinkwasser je nach dem Wassergehalt der Futterration verschieden hoch ist. An säugende Häsinnen und bei großer Hitze wird man Trinkwasser geben, auch wenn Grünfutter bis zur Sättigung gereicht wird.

Der Umstand, daß die Kaninchenhaltung als bäuerlicher Betriebszweig keine Bedeutung hat, sondern die Kaninchenzüchter in weit überwiegendem Umfange anderen Berufsgruppen angehören, mag der Grund dafür sein, daß keine Zahlen über die Futterausnutzung beim Kaninchen bestehen. Wir sind bei Futterberechnungen vielmehr gezwungen, uns auf die bei Wiederkäuern und beim Schwein gefundenen Zahlen zu stützen. Um diesem Übelstand abzuhelfen, wurden von H. Brüggemann mit verschiedenen Futterstoffen Ausnutzungsversuche beim Kaninchen durchgeführt, deren Ergebnisse in nachstehender Tabelle wiedergegeben seien.

Jn 100 g sind enthalten in g:

	Verdaul. Eiweiß Prozent	Gesamt-Nährstoffe Prozent
Wiesenheu	5,2	39,1
Luzerneheu	16,6	48,5
Brennesselheu	20,8	51,9
Grüne Luzerne	5,6	15,8
Grüne Süßlupine	3,3	8,9
Maisgärfutter	1,3	12,7
Hafer	10,3	57,1
Gerste	9,7	77,2
Weizen	10,9	82,2
Futterrüben	0,3	10,9
gedämpfte Kartoffeln	1,3	22,0

Es ist sehr wünschenswert, daß derartige Untersuchungen auf weitere Futtermittel ausgedehnt werden, denn Brüggemann hat beim Kaninchen beträchtliche Abweichungen gegenüber der Futterausnutzung der großen Haustiere erwiesen. Das bezieht sich insbesondere auf die Verwertung der Rohfaser gegenüber den Wiederkäuern. Die Feststellung des Verdauungskoeffizienten beim gleichen Wiesenheu ergab z. B.:

	beim Kaninchen Prozent	beim Schaf Prozent
Rohprotein	60,1	60,1
Reineiweiß	63,5	59,0
Rohfett	43,1	32,0
Rohfaser	18,5	72,4
N-freie Extraktstoffe	64,5	75,6

Hieraus muß die eindeutige Überlegenheit des Kaninchens gegenüber den Wiederkäuern hinsichtlich der Rohfaserverdauung abgeleitet werden.

Jn diesem Zusammenhang seien auch Mangold's Untersuchungen über die Verfütterung von Sägemehl erwähnt, welche von einer Reihe von Kaninchenzüchtern in einer übertriebenen Weise befürwortet wurde und zu umfangreichen Auseinandersetzungen führte. Außer neuen Daten über die Durchgangszeiten beim Kaninchen konnte Mangold feststellen, daß die Rohfaser im Sägemehl nur zu 2–6 Prozent verdaut wurde. Er spricht dem Sägemehl daher eine Bedeutung als Nährstoff, der als Ersatz für andere Futtermittel dienen könnte, ab, wobei die Möglichkeit einer rein diätetischen oder hygienischen Wirkung als nicht ausgeschlossen bezeichnet wird,

Über die spezielle Wirkung von Futterzusätzen, wie Lebertran Vitamin- und Mineral-Präparate liegen keine ausreichenden Erfahrungen vor. Aber ihre ständige Verabreichung wird als überflüssig abgelehnt, weil die in ihnen enthaltenen Ergänzungsstoffe in einer natürlichen und vielseitigen Futterration in ausreichender Menge enthalten sind. Jene Präparate sollen als Heilmittel angesehen werden, denn die Kaninchen können ihre eigentliche Aufgabe nur erfüllen, wenn sie selbst bei Abfallfutter leistungsfähig sind.

ZUSAMMENFASSUNG

Die Kaninchenhaltung ist in Deutschland kein landwirtschaftlicher Betriebszweig und sie wird auch nicht farmmäßig betrieben, sondern sei dient der Verwertung von Küchen- und Gartenabfällen, weshalb sie vor allem in den Randgebieten der Großstädte verbreitet ist. Das Grundfutter besteht im Sommer aus dem Mischwuchs der Wegeränder und aus den Unkräutern der Ödflächen, also aus denjenigen Pflanzen, welche von keiner anderen Tierart genutzt werden. Voraussetzung für eine wirtschaftliche Kaninchenhaltung ist die Sicherung des Winterfutters durch entsprechende Vorräte an Heu, Wurzelfrüchten oder Sauerfutter. Letzteres wird von Kaninchen gern gefressen; die Höhe des Verzehrs wurde durch Versuche festgestellt. Auch über Art und Menge des Kraftfutters liegen Versuchsergebnisse vor. Hiernach bewirken Eiweißgaben keine Steigerung des Wollwachstums, so daß Kohlehydratfuttermittel wie Getreide, Kartoffelflocken oder Zuckerschnitzel genügen und zwar 40 g je Tier und Tag. Brüggemann konnte für eine Reihe von Futtermitteln die Ausnutzungswerte bei Kaninchen feststellen, wobei sich eine niedrige Rohfaservendauung des Kaninchens gegenüber den Wiederkäuern ergab. Nach Untersuchungen Mangold's besitzt das von einigen Praktikern häufig empfohlene Sägemehl keine Nährwerte. Auch über den Wasserbedarf des Kaninchens liegen inzwischen genaue Angaben vor.

Jn einer Gegenüberstellung des Futterverbrauches und der Gewichtszunahmen beim wachsenden Kaninchen konnten die güngstigsten Schlachttermine bei einer Reihe von Kaninchenrassen ermittelt werden.

SUMMARY

In Germany, the maintenance of rabbits is not a branch of agricultural activities and is not undertaken as such. These animals are mostly kept for the utilization of waste materials of kitchen and garden, which explains their great numbers in the suburbs of large cities. During the summer, their basic feed consists of various kinds of green feed growing along the roads, and of weeds growing on waste tracts of land. These are plants which are not utilized by any other species of animals. A prerequisite for economic keeping of rabbits is the storing of the necessary feed reserves for the winter, consisting of hay, roots, tubers, and silage feed. Silage is relished by rabbits; the level of consumption has been established experimentally. There are also experimental results on type and quantity of strengthening feed. According to these experiments the feeding of protein does not increase wool production, so that carbohydrate feeds like cereals, potato flakes, or chipped sugar beets are sufficient (40 grams per animal per day). Brüggemann was able to establish utilization figures with rabbits for a certain number of feeds. It was found that the digestibility of raw fiber by rabbits is much lower than by ruminants. According to the experiments by Mangold, sawdust often recommended by practitioners is of no nutritive value. There are also exact findings on water requirements of rabbits.

In a comparison of feed consumption and increase of weight with growing rabbits, the most favorable time for slaughter could be established for a number of rabbit breeds.

SECTION 6. POULTRY PRODUCTS RESEARCH

INTRODUCTION

By PAUL F. SHARP,[1] *Professor of Dairy Chemistry, Cornell University, Ithaca, New York, U. S. A.*

The poultry and egg industry, in its organized marketing and processing phases, developed an increasing number of products, coincident with the separation of regions of production from populous centers of consumption. Like many other industries it is confronted with the major problems of overproduction and fluctuations in demand. It is trying to solve its problem of overproduction by finding new uses and increased markets for its products, and it is solving its problem of fluctuations in demand by maintaining reserves in storage. The poultry and egg industry is also confronted with the problem of finding profitable uses for its byproducts. Poultry products have now become specialized subjects for study and research with experts in the various phases.

The production of eggs and poultry is seasonal. In the United States half of the eggs are laid in the four spring months and a part of these eggs must be stored to stabilize their movement into consumption and, correspondingly, to stabilize the industry. Most of the chickens are hatched in the spring months. While the poultry could be kept alive until consumed such procedure would usually be expensive from the standpoint of cost of feed and care, and certainly would not permit the marketing of the smaller sizes of poultry at all seasons of the year. Storage of eggs and poultry is a very important function of the industry today; it makes possible in times of plenty saving for the days of scarcity, and its products are, in consequence, more generally available at a more uniform price to the consumer with a more adequate return to the producer. Many important technical problems have arisen in connection with the storage of eggs and poultry; progress has been made toward the solution of some of them. There is a growing demand for more definite answers to questions, and, in evaluating results, there is a growing insistence that objective measurement and recording take the place of subjective observation and opinion.

The preservation of the flavor and the physical and chemical properties of shell eggs involves problems of procurement, transportation, sanitation, case and filler composition and construction, as well as the more specific problems of storage environment, such as temperature, humidity, air circulation, and air composition.

The fact that eggs are protected by a shell has some disadvantages. There is a tendency to depend on the shell for maintenance of the quality of the contents, rather than on known approved methods of production and handling. The egg must be opened to make sure of what is inside. Candling, without breaking the shell, is the accepted method of estimating what is inside; often, however, rather serious mistakes are made. One need in the great shell-egg industry is a more reliable method for determining the quality of the contents of individual eggs without breaking the shell.

To an ever increasing degree, eggs are stored in the frozen state after removal from the shell. Knowledge and control of the bacteriological and sanitary factors involved in breaking and freezing eggs are therefore also important from the standpoint of the production of a safe, desirable product. Freezing produces physical changes in the egg yolk which are interesting chemically and are of importance in connection with some of the uses of frozen yolks. The control and determination of the color of yolks and the amount and character of the color contributed to foods by the yolks is in need of further study.

Dried eggs are satisfactory for many purposes, but chemical and physical changes occur which alter their properties. In order to obtain dried white that will whip, the protein must be altered previous to drying or the dried product must be aged or processed. Although a large volume of foam can be produced with processed dried white there still remain unsolved problems in connection with stability, drainage, and failure in certain uses. The emulsifying and foaming properties of eggs should be more thoroughly investigated.

We greatly need more detailed knowledge of the actual chemical composition of egg white and egg yolk. Such information would be of value from the standpoint of utilization and preservation of eggs. We should have a more thorough knowledge of eggs from the nutritional standpoint. Our information is meager as to the function of eggs in cooking.

Tremendous changes have been made in the marketing of edible poultry. These changes are

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in the direction of making the poultry more convenient for the cook and housewife, as well as for shipping and storage. In most urban centers poultry prepared for cooking can be obtained at any time in the year in a range of weights. Problems are involved in the marketing of drawn poultry, many of which may not be completely solved for years to come—such problems as selection of poultry, feeding, killing, scalding, picking, eviscerating, packaging, the rate of freezing, the storage environment, preservation of bloom, sanitary inspection, and control. Methods of cooking and serving poultry in hotels and restaurants are notoriously poor, and the poultry industry would do well to study the factors involved in large-scale cooking with a view to improving this outlet.

Problems of profitable utilization of feathers, legs, heads, viscera, egg shells, infertile incubator eggs and inedible eggs, and so forth, arise. Certain grades of feathers find a market, but we know very little about the possibilities of utilizing most of these other products mentioned, except as tankage or fertilizer. It is possible that a careful study would reveal hidden values in the proteins, fats, or other organic materials present in these byproducts. Studies should be made of the possibility of separating useful physiologically active substances from the byproducts of the cleaning or dressing plant.

In our attempt to find new uses for poultry products we should bear in mind that the industry is built upon the utilization of poultry and eggs as human food, and for such use these products can be sold at a relatively high price. As soon as we attempt to find new nonhuman food uses, we usually enter a low priced market where the poultry products must compete with products from other relatively cheaper sources. In general, the great industrial utilizations of agricultural products have occurred only with the natural direct products of the soil, and not with the converted products such as poultry and eggs.

DIE DURCHLÄSSIGKEIT DER EISCHALE FÜR DIE BAKTERIEN UND IHRE BEDEUTUNG FÜR DIE KÜHLHAUSLAGERUNG

Von Dr. Heinz Rievel, *Aus dem Institut für Lebensmittelhygiene der Universität Berlin, Deutschland*

Die im Laufe der Jahreszeiten sehr stark wechselnde Eierproduktion zwingt dazu, die Eier im Frühjahr zu konservieren, um den Verbraucher während des ganzen Jahres mit Eiern zu versorgen und dem Produzenten einen angemessenen Erlös zu sichern. Da die Eier einer natürlichen Zersetzung unterliegen, ist es notwendig, Eier zu konservieren. Als Konservierungsmethode kommt heute wesentlich nur noch die Kühlhauslagerung in Betracht. Die Kühlhauseier lassen sich durchschnittlich 5 bis 8 Monate uneingeschränkt gebrauchsfähig halten, doch ist damit zu rechnen, daß eine gewisse Anzahl verdirbt. (Rasmusson (*1*), Beller, Wedemann, und Priebe (*2*)). Die Zersetzungsvorgänge bei Eiern sind entweder chemisch oder bakteriell bedingt. Die chemische Zersetzung beruht auf der Einwirkung von Enzymen, welche eine Selbstverdauung der Eier einleiten, die sich durch den typischen Geschmack nach alten Eiern zu erkennen gibt. In dem Ausmass der Veränderung werden die chemischen Zersetzungen bei weitem übertroffen durch die bakteriellen. Die an der Zersetzung beteiligten Keimarten sind je nach der Aufbewahrungsart der Eier verschieden. In eigenen Versuchen (*3*) konnte festgestellt werden, daß die Eierzersetzung bei Zimmertemperatur überwiegend durch *Proteus*bakterien und bei der Kühlhauseinlagerung überwiegend durch Fluoreszenten hervorgerufen wird. Fluoreszenten in verdorbenen Kühlhauseiern wurden ausserdem von Wundram (*4*), Wundram-Schönberg (*5*), Grzimek (*6*), Janke und Jirak (*7*), Wiidik (*8*), und Schell (*9*) festgestellt, die daraus auf eine Infektion der Eier während der Kühlhauslagerung schliessen, nachdem zuvor die Fluoreszenten durch Horowitz (*10*) im Kühlhaus nachgewiesen waren. Es ist eine von jeher umstrittene Frage gewesen, ob die Keime, welche die Eizersetzung bewirken, primär im Ei vorhanden waren, oder erst nachträglich durch die Eischale eingedrungen sind. Ein grosser Teil der Forscher stand etwa um die Jahrhundertwende auf dem Standpunkt, daß Keime primär im Ei vorhanden seien, und zwar nahm man an, daß u.a. infolge der Begattung der Hennen von der Kloake aus Keime in den Eihalter und in die Eier selbst gelangen. (Zimmermann (*11*), Cao (*12*), Poppe (*13*), Pennington (*14*), Maurer (*15*), Bushnell und Maurer (*16*)). In der unmittelbaren Vorkriegszeit änderte sich die Ansicht dahin, daß frische Eier, sauber in einwandfreien Beständen gewonnen, überwiegend (mit Ausnahme von 5 bis 10 Prozent) keimfrei seien. (Schrank (*17*), Menini (*18*), Rettger (*19*), Kossowicz (*20*), Portolka (*21*), Hadley and Caldwell (*22*), Andresen (*23*), Altemeier (*24*), u.a.) Das bakteriell bedingte Verderben von Eiern musste demnach zu einem wesentlichen Teile durch das Eindringen von Keimen durch die Eischale verursacht werden. Zur Stützung dieser Annahme hat man vielfach versucht, experimentell den Nachweis zu führen, daß Keime von aussen durch die Eischale einzudringen vermögen. Die ersten derartigen Versuche sind Mitte des vorigen Jahrhunderts von v. Wittich (*25*) mit Schimmelsporen gemacht worden. Durch die Züchtungsversuche von Choleravibrionen im Ei zum Nachweis der H_2S-Bildung (Hueppe (*26*), Zenthöfer (*27*), Abel und Dräer (*28*), Hammerl (*29*), Dönitz (*30*), Gruber und Wiener (*31*)) wurde das Interesse für ein spontanes Einwachsen von Choleravibrionen und anschliessend für das Eindringen anderer Keimarten in Eier sehr gefördert. Eine grosse Zahl von Durchwachsungsversuchen wurde vorgenommen, die in ihrer Technik alle der von Hueppe (*26*) angegebenen folgen (Zörkendörfer (*32*), Wilm (*33*), Piorkowski (*34*), Golowkow (*35*), Lange (*36*), Sachs-Mücke (*37*), Baumgarte (*38*), u.a.). Bei all diesen Versuchen wurden die Eier zunächst mit heissem Wasser, Seife und Bürste gescheuert und anschliessend etwa 1 Std. in Sublimatlösung eingelegt. Nach einer mehrstündigen Wässerung in Aqua dest. wurden sie für die Durchwachsungsversuche benutzt, indem sie zumeist in Bouillonkulturen eingelegt wurden. Derartige Versuche sind in gleicher Durchführung bis in die Jetztzeit insbesondere von medizinischer Seite vorgenommen worden. Erst allmählich brach sich die Erkenntnis Bahn, daß durch die bisher üblichen Vorbehandlungen der Eier wie Abbürsten mit heissem Wasser und Seife und das Einlegen in Desinfektionslösungen und Aqua dest. die Oberhaut des Eies aufs schwerste geschädigt wird. Das hat zur Folge, daß mit einer erhöhten Durchlässigkeit gerechnet werden muss, da nämlich weder die Kalkschale noch die innere Schalenhaut wegen ihrer Grobporigkeit das Durchwachsen der Keime zu verhindern vermögen. Mit Rücksicht auf die angewandte Technik sind daher die bisherigen Versuche nicht als beweiskräftig anzusehen. Diese Einwände sind erst kürzlich auch von Wiidik (*8*) gemacht worden, der die von Heinrich (*39*), Kossowicz (*40*) und Poppe (*13*) gemachten Versuche wegen der Unterlassung der Reinigung rühmt. Heinrich (*39*) konnte in Eiern, die er in Wasser mit Kulturabschwemmungen einlegte, dieselben Keime wieder nachweisen. Kossowicz (*20*) hing über steril verwahrten Eiern mit Kulturen getränkte Wattebäusche und Papierstreifen so auf, daß die Eier nicht benetzt oder berührt wurden. In den Eiern fanden sich die Keime nicht. Nach dem Aufbringen von Bouillonkultur auf die Eier wuchsen die Keime in das Innere. Poppe (*13*) bestrich Eier mit Kot, aus dem *Paratyphus-B* Keime in das Ei einwuchsen, während unbewegliche Keime wie Rotlauf und Geflügelcholera nicht eindrangen. Wiidik (*8*) benutzte unbehandelte Eier und betupfte sie mit einer Bouillonaufschwemmung von Fluoreszenten. Sämtliche Eier wurden durchwachsen und zwar bei 18° nach 3 Wochen, bei 8° nach 3½ Wochen und bei: −0° nach 4 Wochen. 6 Eier wurden dadurch infiziert, daß sie in einen Eisschrank gelegt wurden, in dem vorher 2 ccm Fluoreszenzbouillonkultur zerstäubt worden war. Nach 7 Wochen waren Fluoreszenten in den Eiern nachzuweisen. Wiidik (*8*) folgert aus den Versuchen, daß nur saubere Eier in das Kühlhaus eingelagert werden dürfen und daß einer Infektion mit Fluoreszenten im Kühlhaus durch trockene Lagerung und Fernhaltung von fluoreszenzhaltigen Waren wie Fischen und Gemüsen vorzubeugen sei. Die Versuche von *Wiidik* wurden von Schell (*19*) bestätigt, der in zersetzten Kühlhauseiern überwiegend Fluoreszenten fand, während die Kühlhausluft relativ wenig Fluoreszenten enthielt. Im Gegensatz zu diesen Versuchen konnten sich Wedemann und Moser (*41*) nicht vom dem Eindringen von Fluoreszenten in die Eier überzeugen, obwohl sie in ihren Experimenten die Eier mit Kochsalzabschwemmung beimpften. Sie halten ein Eindringen von Fluoreszenten während der Kühlhauslagerung für unmöglich. Als Einwand gegen den Nachweis des Eindringens von Fluoreszenten machen sie geltend, daß die Fluoreszenten auch shon primär im Ei enthalten sein könnten Schönberg und Wiidik (*42*) versuchen den Widerspruch damit zu klären, daß von Wedemann und Moser (*41*) unbewegliche Fluoreszenten zur Infektion benutzt wurden.

Der bestehende Streit der Meinungen gab Veranlassung, eigene Durchwachsungsversuche unter Anwendung einer neuen Technik vorzunehmen und damit die strittige Frage einer Klärung näher zu bringen. Voraussetzung für die Versuche war, daß die Eischale selbst keine Behandlung vor der Infektion erfahren durfte, um die natürlichen Verhältnisse möglichst wenig zu verändern. Das neue Verfahren sucht die Nachteile der bisherigen Methode zu vermeiden, daß sich nämlich bei dem Nachweis der Fluoreszenten im Eiinhalt diese im Ei erst sehr angereichert haben müssen, ehe sie nachweisbar sind. Ein weiterer Nachteil der bisherigen Methode liegt darin, daß sich die Keime nie mit Sicherheit an der Infektionsstelle selbst nachweisen lassen.

Zur Vermeidung dieser Mängel wurde ein Verfahren ausgearbeitet, wie es in der Milchbakteriologie üblich ist, um die Sauberkeit der Milchflaschen nachzuprüfen, in dem die Eischale nach Entleerung des Eiinhaltes mit einer dünnen Agarschicht ausgegossen und aussen auf der Schale eine Infektion mit verschiedenen Kulturmedien und zwar Bouillonkultur, Kochsalzabschwemmungen und trockenen Fluoreszenz-Schrägagarkulturen vorgenommen wurde. Falls die Fluoreszenten durch die Eischale hindurchwachsen, entwickeln sie sich auf der Agarschicht und erzeugen dort eine deutlich grüne Färbung. Bei der technischen Druchführung ist ein vorsichtiges Arbeiten notwendig, um den Eininhalt steril und ohne Verschmutzung der Eioberfläche zu entleeren. Mit den Eiern wird zunächst eine Durchleuchtung vorgenommen und der Sitz der Luftkammer bestimmt. Oberhalb der Luftkammer wird dann mit einer kurzschenkeligen Schere eine stecknadelkopfgrosse Öffnung in die Eischlae gestossen, nachdem der zugehörige Eipol in Alkohol getaucht und energisch abgebrannt war. Diese Öffnung wird erweitert, indem durch ein spiralförmiges Rundschneiden (nach Art des Kartoffelschälens) mit der Schere ein stets nur ein bis zwei mm breiter Streifen von der Eischale abgeschnitten wird. Wenn die Öffnung einen Durchmesser von etwa 1 cm erreicht hat, wird das Ei mit schnellem Griff nach unten gekehrt, um das Eiweiss ausfliessen zu lassen, während der kugelige Dotter noch im Ei zurückbleibt. Durch eine ebenso schnelle Drehbewegung richtet man das Ei wieder auf und vergrössert durch weiteres, spiralförmiges Rundschneiden die Öffnung auf einen Durchmesser von 2 bis 3 cm und entleert anschliessend den Dotter. Dotter und Weissei müssen in sterilen Petrischalen aufgefangen werden, damit Abimpfungen auf Agarplatten vorgenommen werden können, welche die Keimfreiheit der zum Versuch bestimmten Eier beweisen müssen. Zum Schluss wird die Öffnung maximal erweitert, da sie später einen freien Einblick in das Innere gewähren soll, der erschwert würde, wenn die Öffnung zu klein wäre. Nachdem der Rand der Schale glatt geschnitten ist, wird das Ei mit der Öffnung nach unten in sterile Glasgefässe gestellt, um die Reste des Eiweisses ablaufen zu lassen, dessen letzte Spuren im Brutschrank angetrocknet werden. Anschliessend wird verflüssigter und auf etwa 50° heruntergekühlter Agar in einer Menge von etwa 8 ccm in die offene Eischale gegeben und durch rotierende Bewegungen darin zu einer Schicht ausgerollt. Nachdem der Agar angetrockent ist, wird das Ei äusserlich mit der jeweils gewünschten Kultur durch Betupfen mit einer Öse infiziert und die Infektionsstelle durch Umrändern mit einem Bleistiffstrich gekennzeichnet. Schliesslich wird das so beimpfte Ei in ein steriles Glasgefäss gelegt und täglich beobachtet.

Da die Fluoreszenten nach eigenen Versuchen (*3*) die Eigenschaft haben, unter den ultravioletten Strahlen der Analysen-Quarzlampe intensiv blaugrün zu leuchten und zwar zu einer Zeit, während der bei gewöhnlichem Tageslicht noch keine Grünfärbung zu erkennen ist, empfiehlt es sich, die infizierten Eischalen täglich unter die Quarzlampe zu halten. Wenn die Fluoreszenten von der aussen markierten Infektionsstelle einzudringen beginnen, zeigt sich an der entsprechenden Stelle in der Agarschicht im Eiinnern eine ganz deutliche, hell-grünliche, circumscripte Lumineszens, die sich von Tag zu Tag verstärkt, bis man auch bei Tageslicht die Grünfärbung erkennt, die sich dann schnell über die gesamte Agarfläche im Innern der Schale verbreitert. Wegen der Schnelligkeit der Ausbreitung ist es notwendig, die Ablesung täglich vorzunehmen, um die Ausgangsstelle mit Sicherheit zu ermitteln. Bei den Versuchen mit mehreren hundert Eiern konnten wir in 5 Fällen beobachten, daß die Kulturen bis zu 1 cm von der Infektionsstelle entfernt aufgingen, wobei sich die Kolonie immer der Schwere folgend nach unten zu verschiebt. Diese Tatsache ist sehr leicht damit zu erklären, daß die Poren und Hohlräume der Eischale nicht senkrecht durch die Schale hindurch führen, sondern nach v. Wittich (*25*) im rechten Winkel verlaufen. Es werden daher die Fluoreszenten diesen Wegen folgen und die Schale nicht senkrecht, sondern im Winkel durchwachsen und sich von der Eintrittsstelle der Schwere folgend nach unten zu ausbreiten.

Der Vorteil der beschriebenen Methode besteht darin, daß an der Eischale sowohl der Zeitpunkt des Eindringens als auch die Eintrittsstelle mit Genauigkeit bestimmt werden können, und sich gleichzeitig der Eiinhalt steril gewinnen lässt. Besondere Bedeutung kommt der Ermittlung der Durchwachsungszeit zu, da sich an der Schnelligkeit des Wachstums die Einflüsse der Infektionsart, der Aufbewahrungstemperatur, der Feuchtigkeit, der etwaigen Reinigung und der Alterung erkennen lassen.

Bei dem Studium der Literatur fand sich nur eine Methode beschrieben, die den Nachweis der durchgewachsenen Kolonien an der Eintrittsstelle anstrebte. Zörkendörfer (*32*) pustete zu dem Zweck Eier aus und füllte sie mit Gelatine. Nach verschiedenen Zeiten wurde die Schale wie bei einem gekochten Ei abgepellt und die Gelatine auf das Wachstum von Kolonien untersucht. Die Methode arbeitet nicht steril und hat den weiteren Nachteil, daß sich der Zeitpunkt des Durchwachsens für das einzelne Ei nicht mit Sicherheit feststellen lässt.

Für die eigenen Versuche bestand der Plan, mit Hilfe der vorbehandelten Eischalen festzustellen, welche Einflüsse die Versuchstechnik, insbesondere die Infektionsart und die Versuchsumstände auf das Eindringen von Fluoreszenten haben. Die Ergebnisse sollten zur Klärung der bisher noch umstrittenen Frage der Durchwachsung beitragen, die für die Kühlhauseinlagerung von Bedeutung ist. Zu dem Zweck wurden 3 verschiedene Infektionsarten geprüft, und zwar: 1.) mit einer Öse einer Schrägagarkultur, 2.) mit einer Öse einer Kochsalzabschwemmung von einer Schrägagarkultur und 3.) mit einer Öse Fluoreszens-Bouillonkultur. Da die Versuche auch noch andere Gesichtspunkte berücksichtigen, die hier nicht interessieren, ist die jeweilige Menge der nach 1., 2. and 3. beimpften Eischalen ungleich. Weitere Modifikationen der Infektionsart bestanden darin, daß in Angleichung an die zahlreichen Durchwachsungsversuche (26 bis 39) die Eischalen in beimpfte Bouillon eingelegt wurden, daß ferner 1 Std. eingeweichte (gewaschene) Eischalen und nur eben feucht beschlagene Eischalen mit einer Öse einer Fluoreszens-Kultur beimpft wurden. Von den Einflüssen äusserer Versuchsumstände auf das etwaige Eindringen der Fluoreszenten in die Eischale wurden lediglich die Aufbewahrungstemperaturen berücksichtigt, indem ausser der üblichen Zimmertemperatur von 18 bis 20° noch ein Teil der Eier bei 0° aufbewahrt wurde. Schliesslich wurden zur Kontrolle Eischalen ausschliesslich mit steriler physiologischer Kochsalzlösung betupft, um festzustellen, ob etwa auch ohne künstliche Infektion die Fluoreszenten in die Eischale wachsen würden. Für den Versuch wurden nur solche Eier gewertet, deren Eiweiss und Gelb sich auf Grund kultureller Nachprüfung nach 3 Tagen bei ca 18° als frei von Fluoreszenten erwies.

Für die Versuchsergebnisse der Untersuchungen an 208 Eischalen gilt als Aufbewahrungstemperatur, sofern nicht etwas anderes ausdrücklich angegeben ist, die Zimmertemperatur von ca 18° C. Unter der Durchwachsungszeit ist die Zeitspanne zwischen der Infektion und dem Auftreten der grünen Lumineszens unter der Quarzlampe zu verstehen.

Die Versuche mit den *Kontrolleischalen,* die mit 1 Öse einer sterilen Kochsalzlösung benetzt wurden, ergaben, daß keine einzige Eischale Fluoreszenten enthielt.

Von den 3 in Fluoreszens-Bouillonkultur eingelegten Eischalen sind sämtliche (100 prozent) von den Fluoreszenten innerhalb von 2 bis 4 Tagen durchwachsen. Von den 21 mit 1 Öse einer Fluoreszens-Bouillonkultur beimpften Eischalen sind 14 (67 Prozent) innerhalb von durchschnittlich 6 Tagen durchwachsen.

Von insgesamt 113 mit 1 Öse einer Kochsalzabschwemmung von Fluoreszenskulturen beimpften Eischalen sind 73 (65 Prozent) in durchschnittlich 8 bis 9 Tagen durchwachsen.

Von 5 Eiern, die mit 1 Öse der gleichen Kochsalzabschwemmung beimpft, dann aber bei 0° aufbewahrt wurden, sind sämtliche Eier von den Fluoreszenten durchwachsen, wobei die Zeitdauer sich auf durchschnittlich 23 Tage erhöhte.

Von 23 mit 1 Öse einer Fluoreszens-Schrägarkultur (trocken) beimpften Eischalen sind 8 (35 Prozent) innerhalb von durchschnittlich 10 bis 11 Tagen durchwachsen.

Sofern 1 Öse der gleichen Kultur auf Eischalen geimpft wurde, die zuvor durch kurzfristiges Einstellen in den Eisschrank abgekühlt und, wieder herausgestellt, bei Zimmertemperatur beschlagen waren, ist von 4 Eiern nur 1 (25 Prozent) durchwachsen.

Von 3 Eiern, die durch einstündiges Einlegen in Wasser stärker durchfeuchtet wurden, sind nach Beimpfung mit 1 Öse einer Fluoreszens-Schrägagarkultur sämtliche (100 Prozent) in durchschnittlich 5 Tagen durchwachsen.

Schalen von Eiern, die in ein Öl (Ovanol) getaucht waren, wurden nur zu 15 Prozent von Fluoreszenten durchwachsen. Die Infektion erfolgte meist mit Kochsalzabschwemmung.

Es sind durchwachsen:

	Prozent	
beim Einlegen der Eischalen in Fluoresz.-Bouillonkultur	100	in 2- 4 Tg.
beim Beimpfen der Eischalen mit 1 Öse Fluoresz.-Bouillonkultur	67	in 6 Tg.
beim Beimpfen der Eischalen mit 1 Öse Fluoresz.-NaCl-Abschw.	65	in 8- 9 Tg.
beim Beimpfen der Eischalen mit 1 Öse Fluoresz.-Schrägagarkultur	35	in 9-12 Tg.
beim Beimpfen der Eischalen (feuchte) Öse Fluoresz.-Schrägagarkultur	25	in 11 Tg.
beim Beimpfen der Eischalen (gewaschen) Öse Fluoresz.-Schrägagarkultur	100	in 5 Tg.
beim Beimpfen der Eischalen 1 Öse Fluoresz.-NaCl-Abschw. bei 0° aufbewahrt	100	in 23 Tg.

Der Vergleich dieser Ergebnisse zeigt deutlich, daß der Erfolg der Durchwachsungsversuche wesentlich von der Infektionstechnik abhängt. Am sichersten wachsen die Fluoreszenten bei Anwendung von Bouillonkulturen ein, es folgt in absteigender Reihenfolge die Kochsalzabschwemmung, während von den mit trockenen Kulturen beimpften Eiern nur $\frac{1}{3}$ durchwachsen wird, sofern eine anderweitige Befeuchtung ausgeschlossen ist. Andernfalls (z. B. nach dem Waschen) steigt die Infekionsquote auf 100 Prozent. Wichtig ist ferner, daß durch die Aufbewahrung bei 0° das Einwachsen nicht verhindert, sondern verglichen mit der Zimmermtemperatur um das 3 fache hinausgezögert wird. Aus diesen Ergebnissen lässt sich folgern, dass das Waschen der Eier allen Keimen Zutritt in das Innere verschafft. Damit ist erwiesen, daß die früheren Versuche (*26–39*) zur Ermittlung des Eindringens verschiedener Bakterienarten in Eier wegen der exzessiven Reinigung und Desinfektion nicht zu verwerten sind. Ferner erklären diese Ergebnisse die von verschiedenen Untersuchern (Bryant-Sharp (*43*), Grzimek (*45*, *44*), Rievel (*3*), Wagner (*46*), Zurek (*47*)) festgestellte Gefährlichkeit des Waschens für die Haltbarkeit von Eiern.

Die bisher strittigen Meinungen über das Eindringen von Fluoreszenten in Eier lassen sich nunmehr dahin festlegen, dass die Fluoreszenten einzudringen vermögen, dass jedoch die Häufigkeit und die Schnelligkeit des Eindringens von der Art und den Umständen der Infektion abhängt. Das gilt sowohl für die Versuche (und dient als Erklärung für die bisherigen Widersprüche) als auch für die Kühlhauseinlagerung, denn die Versuche bewiesen, dass auch bei 0° C. Fluoreszenten die Schale durchwachsen können.

Vorausszetzungen für eine Infektion der Eier im Kühlhaus sind 1.) das Vorhandensein von Fluoreszenten entweder auf der Eischale (von Verschmutzungen oder vom Waschen vor der Einlagerung herrührend) oder in dem Kühlhausmilieu (z. B. im Raum oder im Verpackungsmaterial) und 2.) das Einwirken äusserer Einflüsse, welche das Eindringen der Keime begünstigen, wie z. B. das Beschlagen (Schwitzen) der Eier. Wie der Versuch und eigene frühere Beobachtungen (*3*) lehren, braucht ein leichtes Beschlagen nicht unbedingt gefährlich zu sein, es ist jedoch bekannt, dass das Schwitzen auch sehr heftige Formen annehmen kann. In solchen Fällen besteht die Gefahr, dass Fluoreszenten aus der Umgebung in die Eier eindringen können.

Jede der erwähnten Voraussetzungen bietet Handhaben zum Ansetzen von Massnahmen, die auf eine Verringerung der Fluoreszens-Infektionen der Eier im Kühlhause hinzielen. Zunächst ist dafür zu sorgen, dass weder die Eier noch die Kühleinrichtungen mit Fluoreszenten behaftet sind, indem nur sauber gewonnene (nicht etwa nur gesäuberte!) und vor allem ungewaschene Eier eingelagert werden. Ferner sind die zur Einlagerung von Eiern bestimmten Kühlräume nicht mit fluoreszensreichen Waren zu beschicken und ausserdem alle Einrichtungen vor dem

Einlagern der Eier zu desinfizieren. Schliesslich sind in dem Betrieb des Kühlhauses alle Einflüsse auszuschalten, die ein Duschwachsen von Fluoreszenten begünstigen können, insbesondere das Schwitzen.

ZUSAMMENFASSUNG

Eier wurden unter sterilen Kautelen und besonderen Vorsichtsmassnahmen so geöffnet, dass 2/3 der Eischale unversehrt blieben. Nach Entleerung des Eiinhaltes wurde das Innere der Schale mit einer dünnen Agarschicht ausgegossen und auf der Aussenseite eine Infektion mit beweglichen Fluoreszenten an einer genau gekennzeichneten Stelle vorgenommen. Das Durchwachsen der Fluoreszenten ist mit eindeutiger Sicherheit daran zu erkennen, dass in unmittelbarer Nähe der Infektionsstelle circumscripte Kolonien aufgehen, die zunächst nur unter den Strahlen der Analysen-Quarzlampe infolge ihrer starken Lumineszenz wahrnehmbar sind. Mit fortschreitendem Wachstum färben die Kolonien den Agar auch bei Tageslicht deutlich grün und breiten sich schnell über die ganze Agarfläche aus. Die Identität der gewachsenen Kolonien ist kulturell zu beweisen.

In einer Menge von 100 Prozent und in 2–5 Tagen wurden gewaschene und in Bouillon eingelegte Schalen durchwachsen, zu 67 Prozent u. in 6 Tagen die mit 1 Oese Bouillonkultur beimpften, zu 65 Prozent u. in 8–9 Tagen die mit NaCl-Abschwemmung, und zu 35 Prozent u. in 9–12 Tagen die mit 1 Oese Schrägagarkultur beimpften Schalen. Die Durchwachsung erfolgte auch bei 0° C. in einer 3 fach längeren Zeit als bei 18° C. Demnach hängt die Fähigkeit der Fluoreszenten, die Eischale zu durchdringen von der Infektionsdosis, der Infektionsart und den gleichzeitigen äusseren Einflüssen ab. Feuchtigkeit in jeder Form begünstigt das Eindrigen von Fluoreszenten ungemein. Deshalb wachsen flüssige Kulturen oder Abschwemmungen am sichersten und schnellsten ein, ebenso sind durchfeuchtete Schalen leichter und schneller zu durchdringen als trokkene. Diese Tatsache vermag sowohl die Widersprüche der bisherigen Durchwachsungsversuche als auch die bekannte Gefährdung der Eier durch das Waschen zu erklären.

Da durch diese Versuche bewiesen ist, dass die Fluoreszenten auch bei 0° C. die Schale zu durchwachsen vermögen, bleibt mit der Möglichkeit zu rechnen, dass diese auch während der Einkühlung in die Eier einwachsen. Voraussetzungen dafür sind 1.) das Vorhandensein von Fluoreszenten entweder auf dem Ei oder in den Kühlanlagen und 2.) das Einwirken äusserer Einflüsse, die das Eindringen begünstigen. Zur Verhütung bzw. zur Verminderung der Kühlhausinfektionen der Eier mit Fluoreszenten ist es erforderlich, dass 1.) nur sauber gewonnene, ungewaschene Eier eingelagert werden und 2.) die Kühlräume von Fluoreszensreichen Waren frei gehalten und vor der Benutzung desinfiziert werden. Schliesslich sind alle äusseren Einflüsse, die eine Infektion begünstigen, insbesondere das Schwitzen zu vermeiden.

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SUMMARY

With the application of particular sterilization precautions, eggs were opened in such a manner that two thirds of the shell remained unbroken. After removal of the content, the interior was covered with a thin agar layer and the outside was infected with motile fluorescents at a clearly marked place. The penetration of the fluorescents may be seen with certainty from the fact that circumscript colonies appear in the immediate vicinity of the point of infection, which at first are only noticeable under the powerful rays of the mercury quartz tube which is used for analytical purposes. With progressive growth, the colonies give the agar a green color, which is clearly visible by daylight, and they spread rapidly over the entire surface of the agar. The identity of the colonies grown may be proved by cultivation.

One hundred percent of washed eggs placed in bouillon were penetrated in 2 to 5 days, 67 percent of eggs inoculated with one loopful of bouillon culture were penetrated in 6 days, 65 percent of eggs inoculated with NaCl suspension were penetrated in 8 to 9 days, and 35 percent of eggs inoculated with one loopful of slant-agar culture were penetrated in 9 to 12 days. The penetration took place even at 0° C., but the time required was three times longer than with 18° C. The ability of fluorescents to penetrate the egg shell is, therefore, dependent upon the quantity of the infective mass, the manner of infection, and other exterior influences. Any form of humidity greatly favors the penetration of the fluorescents. Therefore, liquid cultures penetrate most rapidly and with the highest degree of certainty; moistened shells are penetrated more easily and more rapidly than dry ones. This fact may explain the contradictions in previous penetration experiments as well as the endangering of eggs through washing.

As these experiments have proved that the fluorescents are able to penetrate the egg shell also at a temperature of 0° C., the possibility that the same may also penetrate the eggs during cold storage is to be taken into consideration. The prerequisites in this case are: (1) The presence of fluorescents either upon the eggs or in the storage room and (2) the influence of exterior factors favoring penetration. For the prevention or limitation of the infection of eggs with fluorescents in cooling houses it is necessary (1) that only such eggs be used for storing purposes as have been produced under sanitary conditions and which have not been washed and (2) that the storage rooms be kept free from merchandise highly infected with fluorescents and that they be disinfected before use. All exterior influences favoring infection, particularly "sweating," must be eliminated.

BREEDING FOR MEAT AND EGG PRODUCTION

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Records of mean annual egg production of 200 eggs over a period of 12 years were reported by Lloyd and O'Neil[1] in bred-to-lay strains of White Leghorns, Rhode Island Reds, and Barred Plymouth Rocks. Continuous selection in these University strains has been responsible for such reduction in days to sexual maturity as to bring more than 90 percent of the pullets into production under 215 days. In the years 1935–36 and 1936–37 the mean ages at first egg in the three breeds were between 183 and 200 days. No significant correlation was found between age at first egg and egg production. The correlation between persistency, or length of the laying period, and total egg production, however, was found to be highly significant. The correlation between age to sexual maturity and body weight was only slightly significant in the case of the Rhode Island Reds (1936–37) but not in the Leghorns and Rocks. The correlation between body weight and either size of egg or number of eggs was variable and in most cases lacked significance. No correlation was found in any of the breeds between the meat grade or body conformation of the pullets and egg production.

Since the two objectives of meat conformation and egg production appeared in harmony in the same strains, they are combined in the standard of selection. Pullets certified in Dominion R.O.P. and breeders in approved R.O.P. matings are graded as "U", which is rounded or plump and well fleshed; "V", medium fleshed and sharp-breasted; "I", sharp-breasted or deep and angular. Under Government regulations in Canada such information is provided by the R.O.P. inspectors as a guide to private breeders in selection. To be certified, however, under R.O.P., birds are not required to reach the higher meat grades. In the qualifications required in the birds used for breeding in the University breeding pens they must grade B or better. In fact, the corresponding

[1] U. S. Egg and Poultry Magazine, January, 1939. "Breeding Dual-Purpose Poultry."

grades, A, B, and C, are each divided into three subgrades, as A+, A, and A−, to permit of finer comparison and selection.

An effort was made to secure uniformity in grading through agreement by at least two persons in judging each bird. On account of the personal factor in judging, some variation in the classification of individual birds is bound to occur. Greater accuracy in estimating the amount of fleshing on the breast of the birds might be obtained by the method as devised by Bird and Gutteridge of the Central Experimental Farm at Ottawa. This method involves the use of an instrument to measure the breast angle, which is correlated with the length of keel and distance from keel to corocoid bone, thus giving the volume of fleshing on the breast. It is suggested that the handling method for the determination of quality of fleshing over the whole body might be combined with measurements by this instrument for estimating meat grade. The consistency in grading as obtained by the handling method, however, has been high enough to permit of allocating birds to rather finely divided subgrades with a fair degree of accuracy. This is the method, moreover, that is used in all commercial grading, is very rapid and will probably be the final one used in selection of the partciular bird for breeding in any case.

TABLE 1.—*Weights of White Leghorn, Barred Plymouth Rock, and Rhode Island Red Cockerels at 12 and 16 weeks of age*

Breed	Cockerels	Wt. at 12 wks.	Range in weights	Wt. at 16 wks.	Range in weights
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*
White Leghorns	196	2.55	1.7-3.2	3.42	2.4-4.5
B. P. Rocks	241	2.76	1.8-3.6	3.81	2.8-4.8
R. I. Reds	351	2.88	2.1-3.7	4.10	3.0-5.0

Through selection for meat type in a general way over a period of years, as shown by Lloyd and O'Neil, the percentages of cockerels in the lower meat grades, B− and C's, have been substantially reduced. The improvement in the meat type of the females was even more marked. Since 1936 all males used in the breeding pens have had to grade B+ or A, in 1938 grade A, and in 1939 high A, i.e., A+. On account of the rapid progress that has been made, it is now possible to use grade A females exclusively in the breeding pens.

In the years 1935 and 1936, cockerels were weighed, graded, and observations made as to feather growth at 12, 16, 20, and 24 weeks of age. Considerable variation was found in weights of cockerels of the White Leghorns, Barred Plymouth Rocks, and Rhode Island Reds, as shown in table 1.

In all tests where weights, feathering, and uniform development are concerned, environmental conditions as they may be influenced by the personal factor in brooding management may affect the data. It is extremely difficult, for example, to secure uniform results in different lots of chicks reared under commercial conditions such as existed in this case. The tendency toward overcrowding in the better hatches and the variations of necessity in the space per unit and the condition of the range as the season advances, present problems that practically defy the attainment of satisfactory uniformity in results. Accordingly the weights attained by the birds in this case, are by no means optimum.

As shown in the previous report, in 1937 and 1938 by mating birds of more uniform meat type, substantial reductions were secured in the numbers of cockerels in the lower meat grades and the slow-feathering groups. While the cockerels of the heavy breeds are not ready for market as a rule before 16 weeks, it is not satisfactory as a basis for selection to delay observations of weights and feather growth so long. Moreover, broilers, which are an important source of revenue, are generally marketed at considerably less than 16 weeks. If they are not well feathered at the desirable weight or age, they must be fed longer. If feathering is deferred too long they may be unprofitable. Further to the demand for early feathering in broilers of the heavy breeds, a preference is now shown for a smaller, more compact type of early feathering roasting chicken. In catering to such a market, poultry producers are now requiring a quick-growing, early feathering "streamlined" chicken.

In order to make satisfactory observations of early feathering, young cockerels must be graded just as soon as feathering spreads over the body. In early feathering breeds like the Leghorns, Campines, and Cambars, (the Campine-Barred Rock auto-sexing breed), both cockerels and pullets are well covered with feathers at 4 weeks. The same is claimed by some breeders for the New Hampshire breed,[2] this being one of the reasons for its recent growing popularity. As described and illustrated in the report,[3] McRae of Oregon has produced families of Rhode Island Reds in which the males are as well feathered at 4 weeks as their sisters. The cockerels appear to be "hen-feathered," with long tail feathers similar to those of the pullets. The young males in these families, which apparently are homozygous for early feathering, show an amount and length of feathering over the breasts, backs, and thighs equal to that found on the pullet chicks of the same age. The mature males of these families appear somewhat more hen-feathered than ordinary males. They do have sickles and coverts, however, although considerably modified in length and abundance. Neither do the hackle feathers flow over the back as on most adult males.

While the University of British Columbia strains of Barred Rocks and Rhode Island Reds have been selected for early maturity and feathering for some years, it was not found possible to

[2] The New Hampshires were admitted to the American Standard of Perfection in 1935.

[3] See footnote 1.

make an accurate or satisfactory classification of the feather growth of the young cockerels at 4 weeks. Feathering was somewhat more clearly advanced at 5 weeks, but classification in some instances is uncertain. Even at 6 weeks it was difficult to rate feather growth in some cases. At 8 weeks, however, the feathering was sufficiently advanced to permit of definite classifications. It would appear, therefore, as if these cockerels were

FIGURE 1.—"Early" feathering cockerel at 6 weeks. (Barred Rock × Cambar cross.) Full-feathered at 6 weeks.

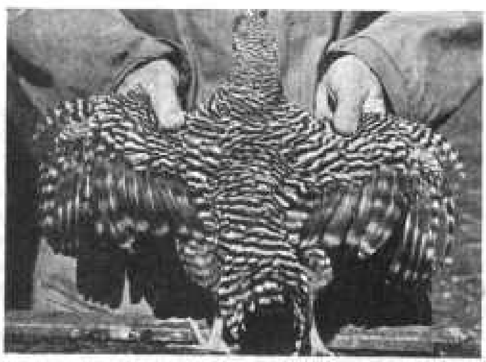

FIGURE 1a.—"Early" feathering cockerel at 6 weeks. (Barred Rock × Cambar cross.) Full-feathered at 4 weeks.

not homozygous for early feathering, like the McRae lines.

It is suggested that at least two observations of rate of feathering be recorded during the critical feathering period as a guide to follow in the selection of both breeding males and females. When the homozygous state of early feathering is obtained it will be possible to detect it at 4 weeks.

A classification found to be feasible for the purpose of differentiation was early, medium early, medium, medium late, and late feathering. Illustrations of these types in Barred Rock × Cambar cross and Barred Rocks are shown at 6 weeks. It

FIGURE 2.—"Early" feathering Barred Rock cockerel at 6 weeks. Not full-feathered at 4 weeks.

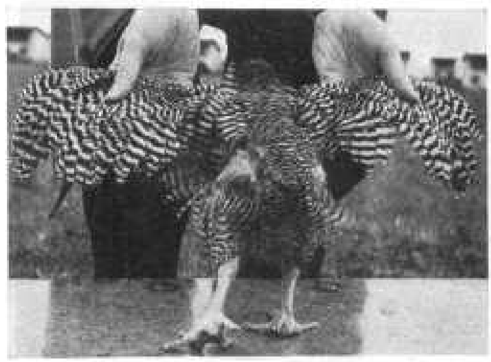

FIGURE 3.—"Medium early" feathering Barred Rock cockerel at 6 weeks.

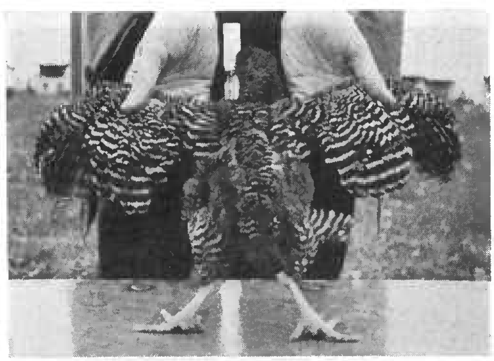

FIGURE 4.—"Medium" feathering Barred Rock pullet at 6 weeks.

will be noted that the "early" group included only those birds, male and female, which, at 6 weeks, were feathered well over the body, showing no bare spots or pin feathers on shoulders or backs. "Medium early" were fairly well covered with feathers, but these included a few half-grown

FIGURE 5.—"Medium late" feathering Barred Rock cockerel at 6 weeks.

FIGURE 6.—"Late" feathering Barred Rock cockerel at 6 weeks.

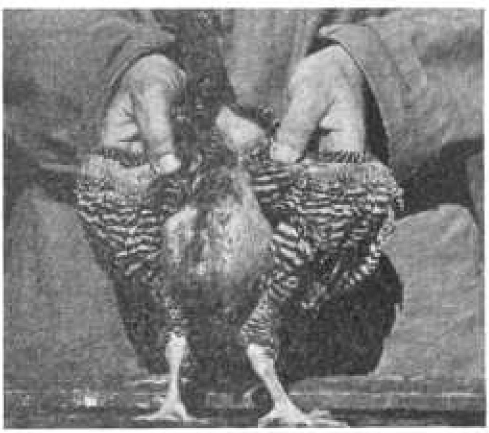

FIGURE 6a.—"Late" feathering Barred Rock cockerel at 6 weeks.

feathers and pins on shoulders and backs. "Medium" were patchy, due to incomplete feathering, with pins or partially grown feathers showing freely on shoulders, backs, and thighs. They appeared to be about midway between the early and late-feathering birds, and were the kind that need more time to develop feathers. A good many of them will go up into the "medium early" group at 8 weeks. "Medium late" showed distinct signs of late feathering in certain large areas of the body where pin feathers predominated. The feathers on wings and patches of the back and breast were normal. The birds of this group, however, did not show the pure late-feathering characteristics of those cockerels on which, with the exception of feathering of primary and secondary flights and thighs, the feathering of the body consisted largely of down. "Early" might be termed as approaching homozygous for full early feathering, including as it does, long tail feathers in cockerels as in pullets. The group "late" would be homozygous for long-deferred and late feathering, or the

TABLE 2.—*Feather growth of Barred Rock and Rhode Island Red chicks*

Breed and sex	Age	Early	Medium early	Medium	Medium late	Late
	Weeks	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Barred Rock:						
Females	6	55.17	25.86	8.63	8.63	1.71
	8	90.91	6.82	....	2.27	....
Males	6	15.07	26.03	24.66	24.66	9.58
	8	36.17	21.28	27.66	10.64	4.25
R. I. Red:						
Females	6	58.33	20.83	12.50	5.56	2.78
	8	53.57	21.43	21.43	3.57	....
Males	6	20.30	26.67	18.18	19.70	15.15
	8	15.00	32.50	22.50	27.50	2.50

type that is generally considered as dominant to early feathering in heavyweight breeds. The three intermediate categories, grading as they do from one into the other, are somewhat difficult to distinguish at 6 weeks, but show up more clearly at 8 weeks.

The distribution of males and females in the different feather groups will be noted in table 2. More than 50 percent of the pullets in the Rocks and Reds in these strains show complete feathering at 6 weeks. There is a considerable percentage, viz, 25.86 percent of the Rocks and 20.83 percent of the Red pullets, however, that show pin feathers at 6 weeks. There are, moreover, about 20 percent of the pullets that fall into the slower feathering categories in each breed. This percentage is greater than was expected in these early maturing strains of birds, especially since the pullets are generally considered to be uniformly early feathering. While the Rock pullets gained rapidly in feather growth between 6 and 8 weeks, there was a considerable percentage (close to 50 percent) of the Red pullets that showed a lag in feather development at the later age. In order to fix early feathering, it is suggested that all pullets not showing completely satisfactory feathering at 6 weeks be kept out of the breeding pens. If there is any doubt because of environmental conditions, no further benefit of any doubt about selection should be given at 8 weeks.

The number of cockerels in the very early feathering groups was of course much smaller than that of pullets. Again, as in the case of the Rock pullets, there was a considerable increase in the number of early feathering males at 8 weeks. The Red males remained more stationary in state of feather in the period between 6 and 8 weeks. This stubbornly slow feather growth in this breed has militated considerably against its adaptation for meat purposes in the past. It would appear as if selection for homozygosity of early feathering in this breed will require drastic selection involving as a first step the elimination of all males and females not showing full early feathering at 6 weeks. Later the homozygous types will show up at 4 weeks, according to McRae.[4]

TABLE 3.—*Mean weights of chickens at six and eight weeks of age*

Sex	Age	White Leghorns	Golden Cambars	Cambar-Barred Rock crosses	Barred Rocks	R. I. Reds
	Weeks	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
Female	6	0.93	1.02	1.26	1.06	0.99
Male	6	1.04	1.08	1.40	1.09	1.22
Female	8	1.41	1.39	1.71	1.47	1.47
Male	8	1.66	1.41	2.01	1.58	1.73

Considerable differences are seen in the early feathering characteristics of the progeny of different males and females. All of the progeny, both male and female, of the McRae Rhode Island Red male (homozygous for early feathering) mated with mixed U. B. C. females were very early feathering at 6 weeks. The progeny of one of the U. B. C. Barred Rock males also showed uniformity for early feathering. It is proposed to intensify these blood lines in breeding.

Table 3 shows the mean weights of pullets and cockerels at 6 and 8 weeks in each of the five breeds, White Leghorns, Cambars, and crossbreds (Campine × Barred Rock), Barred Plymouth Rocks, and Rhode Island Reds.

The first two breeds are dominant for early feathering, while the crossbreds show early feathering through sex-linkage from the Cambar sires that were used in the F_2 generation of the Cambar × Rock cross.[5] (See figures 1 and 1a.) It will be noted that the crossbreds are outstanding over all pure breeds in weights of both cockerels and pullets at 6 and 8 weeks respectively. The Red cockerels, as in previous years, are heavier than the Rocks, but there is little difference between the mean weights of the pullets.

SUMMARY

Bred-to-lay strains of White Leghorns, Barred Plymouth Rocks and Rhode Island Reds, mean egg production of 200 eggs and higher in twelve months, selected in general for standard type, since 1935 have been graded, selected and bred for improved meat type.

No correlation has been found to exist between egg production and meat type, egg production and days to sexual maturity, or between sexual maturity and body weight. A significant correlation was found in two cases out of six as between body weight and egg production, but it was not consistent. The correlation between body weight and egg size was positive and significant in 50 percent of the cases. The only highly significant correlation found was that between the length of laying period and total egg production.

In the Barred Plymouth Rocks and Rhode Island Reds the percentage of birds reaching the highest meat grade (A) has been 70 percent, while the number of slow-feathering males has been reduced from 6 percent to 3 percent and from 30 percent to 10 percent respectively. The number of B grades has been decreased, and the number in the lowest grade (C) has been reduced to a minimum in each case. In some families the males feathered out as early as the females.

Results would indicate the absence of any correlation between egg production and meat grade in the University strains of poultry.

[4] See footnote 1.

[5] This stock was part of the progeny of the back cross of the F_1 crossbred Cambar pullets to pure Cambar males. The latter were progeny of Cambars bred by Pease and Punnett of Cambridge University from Gold Campines and Barred Rocks from the University of B. C. in 1931. The Gold Cambar is one of the auto-sexing breeds developed at Cambridge and now being improved through the introduction of more high producing Barred Rock blood at U. B. C.

BACTERIAL CONTAMINATION OF FROZEN WHOLE EGGS AND AN IMPROVED METHOD OF DEFROSTING

By D. S. Brownlee, *and* L. H. James, *University of Maryland, College Park, Maryland, U. S. A.*

The numbers of bacteria in egg products have been considered by some people to be of minor or of no importance. However, the time is not far distant when the type and extent of microbial decomposition that takes place in egg batter will be directly associated with the physical and chemical characteristics that are so essential to a satisfactory product.

Information is not available either to prove or to disprove this statement, but the accumulation of data which may some day relegate this moot question to its proper place is most timely.

Extensive studies of the influence of shell egg quality upon the microbial condition of the resulting frozen eggs have been reported by Redfield (*8*), Stiles (*9*), and Pennington (*7*). Suffice it to state that the better the shell egg at the time of breaking the better will be the quality of the frozen batter.

The interests of the egg packer do not cease when the product is frozen, however. Just as the automobile manufacturer is interested in the public's obtaining the greatest service from his car, so the egg packer is concerned that his products meet the consumer's needs. He must understand the requirements and must know the treatment his product receives in the consumer's hands.

The defrosting of frozen eggs is carried out entirely independent of the egg packer, yet it can be so conducted as greatly to alter the character of the egg material. Considering the perishability of egg meats the methods used for defrosting should be developed only under scientific investigations. Unfortunately there has been no work reported on the bacteriological changes occurring in the defrosting of frozen eggs under commercial conditions. Niles (*6*) reports that "some large bakers are using a new method with considerable success, by which hot air is forced over the cans, accomplishing the thawing in about eight hours." Since the time of defrosting is reduced from approximately 30 hours to 8 hours, it is obvious that the temperature of the outer layers of defrosted egg meat must be considerably above the freezing point, a factor highly conducive to spoilage.

DEFROSTING UNDER COMMERCIAL CONDITIONS

The cooperation of a large bakery in Washington, D. C., has made it possible to study the defrosting of frozen eggs under commercial conditions. At that plant 30-pound cans of eggs were held in cold running water at 11.5° C. (automatic controlled-brine cooled). Approximately 25 hours were required completely to defrost the egg meats. During this holding period samples were collected and analyzed.

Samples of egg material were obtained from three positions in each can: A, from the outside edge of the frozen egg material; C, from the middle of the can; B, from a point midway between the outside edge of the frozen material and the middle of the can.

Approximately three inches of the frozen egg was removed aseptically from the top of each can by means of sterile chisels. A sample was then collected from each of the three areas indicated above into sterile bottles for immediate analysis as described below. The can tops were then replaced securely and the cans either put into the tank of water or fastened into a special defrosting machine.

Eggs defrosted in the tank by the commercial method were examined hourly to determine the rate of defrosting and to record temperature changes both inside the can and in the water in the tank. Samples of these egg materials were collected only at periods of 6, 18, 19, 21, and 25 hours after the cans were put into the defrosting tank. Owing to the slow rate of defrosting only samples from position A of the can could be obtained after 6 hours; samples from position A and B were collected after 18 hours; samples from positions A, B, and C were obtained in each remaining time interval.

Samples of the defrosted egg material in each area were obtained from a point approximately three inches below the surface of the eggs by means of sterile 10 cc pipettes.

FAST DEFROSTING WITH NEW MACHINE

The other defrosting method was designed to produce a more rapid transmission of heat into the frozen egg material. A machine was built in which the can of eggs, immersed in cold water, was given a short rotating motion. For these preliminary studies a wooden tub was provided, into which a rotating bracket for holding the egg can was fastened. The rotating motion was secured from an eccentric shaft driven by an electric motor (figure 1).

The rotating motion of the can was limited to approximately two inches and the speed reduced to 75 rotations per minute by means of reduction gears. A continuous stream of cold water from the large defrosting tank was maintained through the wooden tub.

Samples were removed at intervals of 1½, 2½, 6½, and 9 hours after the cans were put in the machine. In order to avoid contamination during sampling the cans were removed from the wooden tub at each interval. Only samples from position A could be obtained at the end of 1½ hours; samples from positions A and B were collected after 2½ hours; samples from positions A, B, C were obtained at each of the remaining time intervals. Samples were not taken after 9 hours as the egg material was then completely defrosted. The rate of defrosting and the temperatures of both the defrosting egg and the water were observed at each sampling interval.

BACTERIA COUNTS

Total numbers of bacteria present were determined by plating in standard methods agar and dextrose agar. Violet red bile agar and eosin methylene blue agar were used in determining the number of *Escherichia coli* organisms present. Meat tubes sealed with agar were used to determine the presence of anaerobic bacteria in the eggs. All plates and tubes were incubated for 72 hours at room temperature (21° C.) and then counted with the aid of a Lumi lens. The number of anaerobic organisms per cubic centimeter of egg was considered to be the reciprocal of the highest dilution showing gas formation.

The bacteria counts of the egg meats defrosted by the regular commercial procedure and by the "fast" process are shown in the tables 1–4. The differences between the two methods of defrosting are strikingly shown in figures 2 and 3.

The temperature of the cooling water in both the open tank and the special apparatus was checked frequently and at no time varied more than ±0.5° C. Temperatures in the cans in the large tank showed a distinct rise, however, after 18 to 20 hours. At the outer edge (Position A) where the microbial activity was greatest, every can of eggs in the tank showed a rise of about 2.0° C. above the water temperature. The region

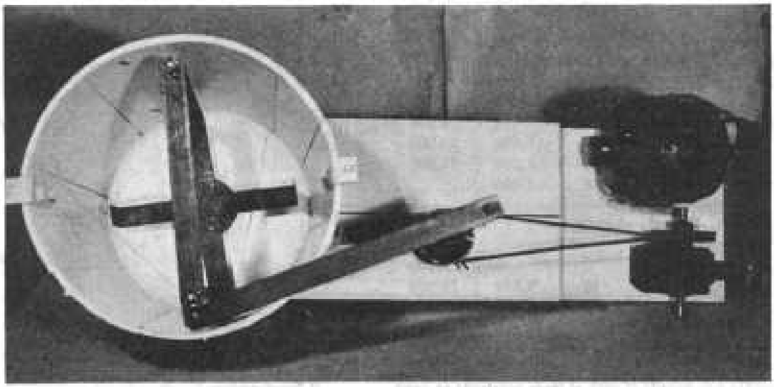

FIGURE 1.—Apparatus used for fast defrosting of 30-pound cans of frozen eggs

TABLE 1.—*Total bacteria counts at each of three positions in cans of frozen whole eggs during slow defrosting*

A (Outside edge)

Position, and time of sampling after defrosting started	Can 1	Can 2	Can 3	Can 4
Frozen sample	16,000	12,000	27,000	167,000
8 hours	42,000	29,000	54,000	520,000
17 hours	71,000	59,000	84,000	4,000,000
20 hours	78,000	73,000	120,000	12,000,000
22 hours	84,000	86,000	180,000	19,200,000
25 hours	108,000	98,000	214,000	....

B (Midway between edge and center)

Position, and time of sampling after defrosting started	Can 1	Can 2	Can 3	Can 4
Frozen sample	34,000	19,000	32,000	213,000
17 hours	76,000	56,000	70,000	1,800,000
20 hours	82,000	68,000	98,000	9,000,000
22 hours	91,000	78,000	160,000	14,300,000
25 hours	117,000	97,000	181,000	....

C (Middle of can)

Position, and time of sampling after defrosting started	Can 1	Can 2	Can 3	Can 4
Frozen sample	34,000	26,000	47,000	204,000
20 hours	61,000	34,000	91,000	5,700,000
22 hours	70,000	51,000	117,000	7,100,000
25 hours	87,000	78,000	137,000	....

TABLE 2.—*Total bacteria counts at each of three positions in cans of frozen whole eggs during fast defrosting*

A (Outside edge)

Position, and time of sampling after defrosting started	Can 5	Can 6	Can 7	Can 8
Frozen sample	26,000	16,500	18,000	14,800
1½ hours	28,000	18,100	19,500	15,900
2½ hours	32,000	21,000	22,700	18,100
6½ hours	41,000	28,000	30,000	24,800
9 hours	46,000	35,000	34,000	27,100

B (Midway between edge and center)

Position, and time of sampling after defrosting started	Can 5	Can 6	Can 7	Can 8
Frozen sample	28,000	18,000	21,000	17,100
2½ hours	30,500	20,000	22,800	18,400
6½ hours	37,000	25,000	28,400	21,700
9 hours	45,600	33,000	32,900	24,800

C (Middle of can)

Position, and time of sampling after defrosting started	Can 5	Can 6	Can 7	Can 8
Frozen sample	32,000	20,500	22,500	18,000
6½ hours	38,000	24,000	27,000	20,400
9 hours	43,000	30,000	31,100	23,700

showing this rise in temperature extended approximately three inches into the egg batter from the metal of the can. This condition undoubtedly stimulated bacterial growth in this outer region. It is interesting to note that whereas in every can examined the initial total bacteria numbers were always highest in the center of the can, yet after slow defrosting the outer areas far exceeded the center in this respect.

TABLE 3.—*Escherichia coli counts at each of three positions in cans of frozen whole eggs during slow defrosting*

Position, and time of sampling after defrosting started	Can 1	Can 2	Can 3	Can 4
A (Oustide edge)				
Frozen sample	0	0	0	1,000
8 hours	0	0	0	1,000
17 hours	0	0	1,000	7,500
20 hours	0	0	2,000	11,000
22 hours	0	0	3,000	10,000
25 hours	0	0	2,000	....
B (Midway between edge and center)				
Frozen sample	0	0	0	500
17 hours	0	0	1,000	6,000
20 hours	0	1,000	1,000	10,000
22 hours	0	3,000	3,000	11,000
25 hours	0	4,000	5,000	....
C (Middle of can)				
Frozen sample	0	0	0	1,000
20 hours	0	10	8,000	14,000
22 hours	0	2,000	9,000	18,000
25 hours	0	2,000	14,000	....

TABLE 4.—*Escherichia coli counts at each of three positions in cans of frozen whole eggs during fast defrosting*

Position, and time of sampling after defrosting started	Can 5	Can 6	Can 7	Can 8
A (Outside edge)				
Frozen sample	10	0	10	10
1½ hours	10	10	20	10
2½ hours	10	10	20	10
6½ hours	60	170	60	60
9 hours	200	340	140	110
B (Midway between edge and center)				
Frozen sample	100	0	30	10
2½ hours	100	100	40	20
6½ hours	200	280	70	50
9 hours	300	370	130	180
C (Middle of can)				
Frozen sample	100	10	10	10
6½ hours	200	200	80	20
9 hours	340	410	100	70

The results from Can 4 offer significant observations. The initial bacteria count shows a striking influence upon the rate of increase during the period of defrosting. In the samples of the original frozen materials the total bacteria count of Can 4 (table 1) was approximately nine times as great as those of the other cans. During defrosting, the egg material in Can 4 showed far greater spoilage, with a total bacteria count approximately 165 times that achieved in the other cans. Thus quality control in the breaking and freezing of eggs, especially as it is related to quality in the defrosted product, has real practical value.

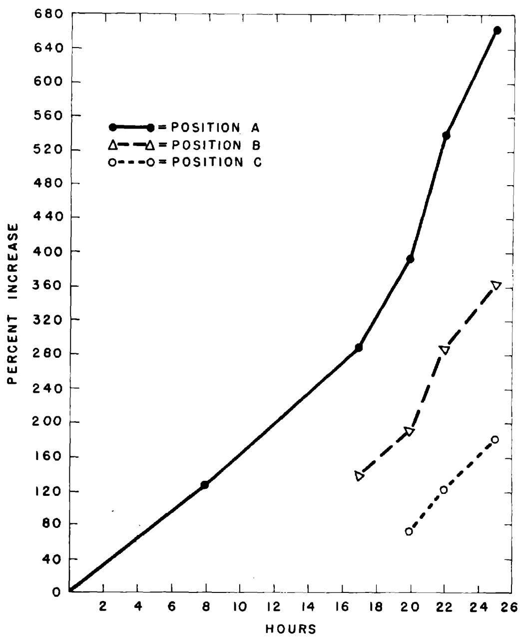

FIGURE 2.—Average percentage increase in bacteria count in frozen whole eggs during slow defrosting.

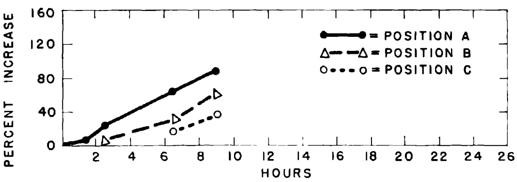

FIGURE 3.—Average percentage increase in bacteria count in frozen whole eggs during fast defrosting.

Temperatures in the cans defrosted under agitation showed no warm zone at any point, in fact the temperatures remained at 11.5° C. or lower throughout the defrosting period. In this case the product was completely defrosted after 9 hours, which may have been too short a period of time for a rise to appear. It is unlikely that any would occur in this method of defrosting, however.

One important observation on the general character of the defrosted product was recorded.

It is common belief that frozen yolks and whole eggs must be defrosted slowly in order to permit an opportunity for the protein, which has been dehydrated by the freezing process, to reabsorb the water released from the thawed ice crystals. While this may be true, nevertheless, the batter defrosted under agitation showed a much more uniform and heavier consistency and was distinctly smoother than any batter ever observed by us before. Whether this represents a basic advantage over the batter defrosted by the older methods or is simply a macroscopic change in appearance due to mixing has not yet been established.

It may be noted that the bacteria conditions of Can 4 not only showed a much greater initial contamination but also developed excessive bacterial spoilage during the defrosting process, for example, bacteria increased as much as 11,397 percent. When the can was originally examined in the frozen condition it did not have as much color as was present in all other cans of the same lot which were examined. At the end of the defrosting period the egg material had a decidedly offensive odor, denoting actual decomposition of the eggs.

ESCHERICHIA COLI AS AN INDICATOR OF POLLUTION

The finding of *Escherichia coli* lends an added importance to this examination of frozen egg products. Since the work of Dyar and Keith (*1*) and Eyre (*3*) showed that this organism was an inhabitant of the intestines of warm- and cold-blooded animals it has been used as an indicator of pollution, especially where that pollution was of fecal origin. It was recognized, however, that the organism itself was not dangerous, but the fact that its length of life in foods is as long as, if not longer than, that of food-borne disease organisms, notably *Eberthella typhi*, makes it of great importance as an index of pollution. The finding of fecal *Es. coli* in the egg products examined thus indicates, in the language of the food law (Sec. 7), that the product is adulterated, since "it consists in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance."

The significance of *Es. coli* in frozen egg products has been widely discussed and as yet has never been definitely established. Gage (*4*), Emmel (*2*), and King (*5*) have shown that *Es. coli* was an almost constant inhabitant of the droppings of hens. Thus, while the presence of *Es. coli* may not indicate recent human pollution, it may be of great importance as an index of recent fowl pollution. If it were possible to develop a test which would allow a differentiation between avian and human strains of *Es. coli* the isolation of these organisms from frozen eggs would present a clearer picture of the source of contamination incurred during the packing and handling of the eggs. Such a test might allow a determination of the sanitary control employed in the breaking and freezing of the eggs, as well as an idea of whether there was any pollution being carried over in the egg from the hen.

It was for the purpose of developing a simple differential test, if possible, between avian and human strains of *Es. coli* that the following experiments were carried out.

Avian and human strains of *Es. coli* were freshly isolated. The purity of the cultures was established by the usual staining and plating procedures, and also by their reactions to the methyl-red test, Voges-Proskauer reaction, citrate test, and indol test.

TABLE 5.—*Amount of avian and human strains of Escherichia coli at various temperatures after 48 hours incubation*

Incubation temperature	Nutrient broth		Lactose broth		Dextrose broth		E.M.B. Agar		Desoxycholate Agar		Endo's Agar		Violet Red Bile Agar	
	Avian strain	Human strain	Avian strain	Human strain	Avian strain	Human strain	Avian strain	Human strain	Avian strain	Human strain	Avian strain	Human strain	Avian strain	Human strain
20° C.	+++	++	++	++	++	++	++	++	++	++	+	+	++	++
37° C.	++++	++++	+++	+++	++++	++++	+++	+++	++++	+++	+++	+++	++++	++++
48° C.	++	++	+	+	++	++	++	++	++	++	++	++	++	++
55° C.	–	–	–	–	–	–	–	–	–	–	–	–	–	–

– No growth. + Scant growth. ++ Moderate growth. +++ Abundant growth. ++++ Profuse growth.

The first attempt made toward a differential test was on the basis of growth at different temperatures. Since the body temperature of the chicken is higher (42° C.) than that of the human (37° C.) it was thought this would possibly provide such a test. Inoculations were made into standard nutrient broth, lactose broth, dextrose broth, and upon eosin-methylene blue agar, desoxycholate agar, Endo's agar, and violet red bile agar. Incubation of the inoculated tubes and plates was made at temperatures of 20° C., 37° C., 46° C., and 55° C., for periods of 24, 36, 48, 72, and 96 hours. The results, presented in table 5 show no detectable difference between the avian and human strains, thus proving the fallacy of the supposition that the temperature of incubation might prove a means of differentiation between the two strains of *Es. coli*.

The ability of different strains of *Es. coli* to produce gas from carbohydrates often is influenced by the environmental conditions of growth, so that avian and human strains might differ in this respect. Accordingly a quantitative estimation of the gas production in various carbohydrate broths was made. Freshly isolated broth cultures of the organisms were inoculated into fermentation tubes of dextrose, lactose, mannite, levulose, and maltose broths. These were incubated at 37° C. and examined at 24, 48, and 72 hour intervals. Comparative examination of the tubes showed that even on a quantitative basis of gas production no differentiation could be made between the two strains of *Es. coli.*

SUMMARY

The extent of bacterial contamination in frozen eggs and the amount of fermentation permitted prior to use are important factors in the further development of a satisfactory market. A large percentage of the bacteria in frozen whole eggs, frozen yolks, and frozen whites are present as a result of the manipulations in packing and freezing. Extensive improvements in recent years in general have materially improved the quality of frozen eggs, and it is of vital interest to the egg packer that his product shall not deteriorate prior to use. Defrosting frozen eggs in running cold water is widely used, and, where the water is maintained at a low temperature, is considered about the best practice. Investigations show that even at cold temperatures the time required for adequate defrosting permits considerable bacterial growth.

A new method of defrosting in which constant agitation keeps the egg meats well mixed greatly reduces the time required for defrosting and practically eliminates bacterial growth.

Bacteria (*Es. coli*) ordinarily considered indicative of fecal contamination and widely used as a test of sanitary quality occur frequently in frozen egg meats. Investigation throws some doubt on the value of this test in the examination of frozen egg products.

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THE PROFITABLE UTILIZATION OF SOILED SHELL EGGS

By E. M. Funk, *Assistant Professor of Poultry Husbandry, University of Missouri, Columbia, Missouri, U. S. A.*

Producers, distributors, and retailers are confronted continually with the problem of the disposal of eggs having soiled shells. That the interior quality of many of these eggs is excellent can be demonstrated by candling or by breaking the eggs and examining their edible qualities.

Better management practices could increase somewhat the percentage of strictly clean eggs produced, but it is not likely that this percentage could be increased to more than 90 percent. Therefore, as a minimum the industry in the United States alone may expect 240,000,000 dozen eggs with soiled shells each year. Since this problem seems to be a permanent one, it behooves the industry to find for it a satisfactory solution instead of lamenting the fact but otherwise ignoring it.

Improved poultry practices have increased the proportion of clean eggs produced and the development of the frozen-egg industry has created a satisfactory market for many eggs having soiled shells. It is of course desirable that only clean eggs be sold to ultimate consumers.

Many different methods for cleaning soiled eggs have been used with varying degrees of success. The egg trade soon learned that cleaning eggs by washing with water caused spoilage so that a net loss resulted from the cleaning. The use of abrasives became and continues to be the accepted method for cleaning eggs.

Recognizing the advantage of an effective but inexpensive method for cleaning eggs having soiled shells, the Missouri Agricultural Experiment Station made a study during 1936 and 1937 of the use of water containing germicidal agents for washing eggs. It now appears that soiled eggs cleaned with water containing 1 percent of sodium hydroxide, NaOH, (97½ percent pure)

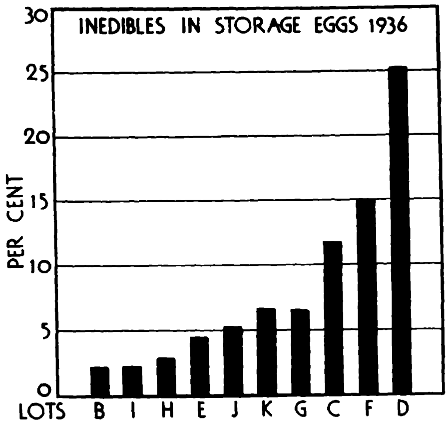

FIGURE 1.—Percentage of inedible eggs taken from test lots of eggs stored in 1936 after washing in germicidal solutions. Lot B consisted of clean eggs not washed. The several lots were treated as indicated in table 1.

eggs were graded by candling and examined for their broken-out appearance.

The experiment, with modifications as given in table 2, was repeated in 1937 with 13,963 eggs. In both seasons the eggs were of storage pack quality as determined by the candlers in a commercial egg packing plant.

1. *Exterior appearance.*—Experienced candlers and observers were unable to separate the eggs which had been cleaned from those which were naturally clean. Men in the egg packing industry report that the addition of some washing powder to this cleansing solution improved the appearance of the eggs cleaned.

2. *Candling appearance.*—After 8 months in a cold-storage warehouse 11,066 eggs were removed from storage and graded by an experienced commercial candler. The results as given in table 2 show that eggs which had been cleaned by washing with a 1-percent solution of sodium hydroxide graded by candling almost as high as did naturally clean eggs. The difference in favor of clean eggs is of little economic importance.

TABLE 1.—*Inedible eggs found by candling and breaking among lots of eggs treated in different ways, 1936*

Item	Clean eggs	Clean eggs washed with water		Dirty eggs washed with—						
				Water	Chlorine solution		Sodium hydroxide		Ethyl alcohol 70 percent	Water and dipped in chlorine solution (.075 percent)
	Lot B	Lot C	Lot E		0.075 percent	0.15 percent	0.7 percent NaOH	0.35 percent NaOH		
				Lot D	Lot F	Lot G	Lot H	Lot I	Lot J	Lot K
Candling results										
Eggs candled.....Number	180	179	180	178	180	167	180	180	174	180
Apparently inedible.....Number	1	10	5	18	7	6	0	1	3	4
Apparently inedible.....Percent	0.56	5.59	2.78	10.10	3.89	3.59	0	0.56	1.72	2.22
Edible (by breaking).....Number	1	2	1	3	4	4	....	1	2	3
Actual inedibles found by candling.....Number	0	8	4	15	3	2	0	0	1	1
Actual inedibles found by candling.....Percent	0	4.47	2.22	8.43	1.67	1.20	0	0	.57	.56
Results by breaking out										
Eggs broken out.....Number	136	131	136	131	133	129	138	132	132	135
Inedible.....Number	4	13	4	30	24	9	5	4	8	11
Inedible.....Percent	2.94	9.92	2.94	22.90	18.05	6.98	3.62	3.03	6.06	8.15
Total inedible.....Number	4	21	8	45	27	11	5	4	9	12
Total inedible.....Percent	2.22	11.73	4.44	25.28	15.00	6.59	2.78	2.22	5.17	6.67

retain their edible qualities as well as eggs which have clean shells.

RESULTS OBTAINED BY CLEANING EGGS

In April, 1936, 1,800 eggs obtained from a commercial egg packing plant were treated as indicated in table 1 and placed in cold storage. Samples of eggs from each lot were removed each month during the 6-month storage period. These

3. *Interior quality.*—Since the exterior appearance of eggs fails to serve as a criterion of interior quality, and candling may not reveal their edible qualities, most of the eggs used in the experiment were broken out and their edible qualities determined by observation and in some cases by cooking. Observations made in 1936 for broken out appearance, which are summarized in table 1, and figure 1, showed that eggs cleaned by

washing with a solution of sodium hydroxide retained their edible qualities equally as well as clean eggs. As a further test of edibility, in 1937, the Department of Home Economics, University of Missouri, made cooking tests on eggs from several experimental lots. Their findings indicated also that the edible properties of eggs which had been washed with a sodium hydroxide solution were equal to those of clean eggs kept under similar conditions.

4. *Market value.*—Realizing that this method of cleaning would not be adopted unless the results obtained had practical applications in the industry, the experiment was planned so that the economic value of the different treatments could be determined in the regular wholesale markets. From three to four cases in each lot were stored for what is usually the maximum storage period (8 to 10 months) in a cold storage warehouse in St. Louis. When removed from storage the eggs were sold by grade to a St. Louis firm for what were considered fair prices for that season of the year. The number of eggs in each grade and the prices received for each grade are given in table 2. The market value of the eggs in each lot are presented in table 3. The average price per dozen was calculated on the basis of all eggs stored and on the basis of the sound-shelled eggs stored in each lot. It is evident from an examination of this table that cleaning the eggs with sodium hydroxide and water was highly profitable. While the soiled eggs averaged only 15.93 cents per dozen, the eggs which had been cleaned properly sold for 19.82 cents per dozen or almost 4 cents more per dozen than the soiled eggs. This represents an increased market value of almost $500 per car. When it is realized that approximately 50,000 cars of these eggs are produced in

TABLE 2.—*Results shown by candling eggs held in storage for 8 months, 1937*

Item	Clean eggs		Dirty eggs		Dirty eggs washed in sodium hydroxide solutions				Price per dozen
	Not washed	Washed in water	Not washed	Washed in water	1.0 percent	0.5 percent	0.25 percent	1.0 percent	
Eggs examined	1,440	1,382	1,440	1,404	1,440	1,440	1,080	1,439	
									cents
Sound clean shells:									
First grade	1,334	1,299	....	1,027	1,280	1,201	870	1,267	0.20
Second grade	63	21	....	252	45	67	40	45	.16
Third grade	9	2	....	32	3	4	4	5	.12
Edible checks:									
Second grade	30	46	37	14	91	110	118	111	.16
Third grade	2	3	1	7	9	23	12	4	.12
Edible dirties:									
First grade	....	....	1,281	....	....	....	....	....	.16
Second grade	....	....	102	....	....	....	....	....	.16
Third grade	....	....	14	....	....	....	....	....	.12
Inedibles	2	11	5	72	13	35	36	8	

The grades first, second, third were those used by the St. Louis firm that purchased the eggs.

TABLE 3.—*Market value of eggs sold by grade in the St. Louis market after 8 months storage in 1937*

Item	Clean eggs		Dirty Eggs		Dirty eggs washed in sodium hydroxide solutions			
	Not washed	Washed in water	Not washed	Washed in water	1.0 percent	.5 percent	.25 percent	1.0 percent
Eggs stored	1,440	1,382	1,440	1,404	1,440	1,440	1,080	1,440
Sound shelled eggs stored	1,408	1,327	1,400	1,347	1,330	1,277	934	1,318
Market value (dollars)								
All eggs	23.58	22.59	19.08	21.06	23.25	22.65	16.76	23.29
Sound shelled eggs	23.16	21.95	18.58	20.80	21.96	20.95	15.07	21.77
Average price per dozen (cents)								
All eggs	19.65	19.61	15.90	18.00	19.37	18.87	18.62	19.41
Sound shelled eggs	19.74	19.85	15.93	18.53	19.81	19.69	19.36	19.82

the United States annually, the magnitude of this loss may be grasped and the enormous savings from proper cleaning visualized. The results secured in this experiment indicate that eggs with soiled shells can be cleaned so that they command not only a better price when sold as current receipts, but also when they are removed from storage and sold by grade.

TABLE 4.—*Bacteria count of frozen eggs, after nine months' storage where the temperature varied from −10° to 10° F., frozen April 9, 1937*

Lot	Treatment	Location of sample	Bacteria per gram at 37° C.
A	Dirty eggs washed in water containing one percent NaOH.	Center—Top	65,406
		Center—Middle	54,711
		Center—Bottom	2,863
		Side—Top	43,896
		Side—Middle	34,353
		Side—Bottom	59,800
	Average		43,504
B	Dirty eggs washed in tap water.	Center—Top	68,388
		Center—Middle	229,022
		Center—Bottom	25,765
		Side—Top	54,075
		Side—Middle	57,255
		Side—Bottom	26,401
	Average		76,818
C	Dirty eggs.	Center—Top	17,495
		Center—Middle	69,661
		Center—Bottom	134,550
		Side—Top	97,970
		Side—Middle	216,298
		Side—Bottom	24,811
	Average		93,465

BACTERIA COUNT OF FROZEN EGGS

Soiled eggs are used quite generally in the frozen-egg industry. This has been one satisfactory way of disposing of soiled eggs during the spring and summer months when most of these eggs are produced. To test the effect of cleaning soiled eggs before breaking on the bacteria count of the resulting frozen-egg product, soiled eggs were cleaned with water and with water containing 1-percent sodium hydroxide and the bacteria count of these frozen eggs determined at the end of 9 months' storage. The eggs were cleaned in the F. M. Stamper Packing Plant, Moberly, Missouri, and the whole eggs were broken out into sterilized standard containers in the egg breaking room of the same plant. The samples for bacterial analysis were removed with a sterile auger from the center and near the sides of the standard 30-pound can at levels near the top, middle, and bottom of the can. The bacteria counts of the samples removed are given in table 4. From the results secured it appears that the bacteria count of frozen eggs was reduced by cleaning the eggs properly before they were broken. As the bacteria count becomes more important in commercial transactions in frozen-egg products, a suitable method for cleaning eggs may have widespread application in the frozen-egg industry.

THE ECONOMIC ASPECTS OF THE PROBLEM

The economic potentialities of some satisfactory method for cleaning soiled eggs are great. Removing soiled eggs from the retail markets and thereby presenting only clean eggs to the consumer should stimulate shell egg consumption. Many eggs with soiled shells have excellent interior quality. Cleaning these eggs properly increases the volume of high quality eggs and therefore increases the national income from eggs, if we may assume that the demand for high quality eggs is not satisfied or that the sale of only clean eggs will stimulate the consumption of eggs.

That the bacteria count of frozen eggs can be reduced by proper cleaning before the eggs are broken makes possible the production of frozen-egg products with a low bacteria count. If the bacteria count of these products becomes a criterion of quality, proper cleaning of eggs consigned to the breaking industry may be profitable.

Soiled eggs have been quite logically discriminated against to the extent of several cents per dozen. With a practical method for cleaning soiled eggs available for the use of the industry the price differential to producers between clean eggs and eggs with soiled shells should be reduced almost to the cost of cleaning. It is desirable that the packers and other dealers do the cleaning, but unless the difference in price paid the producer for clean eggs and for soiled eggs is only slightly more than the cost of cleaning the producers will clean the eggs.

The economic potentialities of the proper method of cleaning eggs may or may not be developed by the poultry industry for some time. But ultimately only eggs with clean shells will be sold in the retail markets.

LUMINESCENCE TEST FOR EGGS

By Ola Grini, *Divisional Chief Veterinary Surgeon, Egg Examination Department, Oslo, Norway*

Fluorescence investigation of unopened eggs under quartz lamp has constantly been dealt with in the literature as a method for determining the age and quality of eggs. The shells of new-laid eggs give red fluorescence, those of older eggs more-or-less blue. At first sight the method seems extremely elegant and striking. On placing a new-laid egg under the lamp we find it to be golden-red, and if we are lucky with an older egg it will prove to be blue.

A luminescence analysis consists in examining the luminance of a substance in filtered ultraviolet light. The filtering eliminates the visible rays and can be varied so to make the pencil of rays more or less narrow.

The fluorescence in the shell is probably due to hematoporphyrin. The red fluorescence is very rare, except in chlorophyll and porphyrin, and in the animal kingdom it may in general be counted as arising from porphyrins. Thus porphyrin has been found in very many animal organs, being present, for example, in the amnionic fluid in sheep. Especially well known is the medicamental porphyrinuria in man. Porphyrin has also been detected in fungi.

FINDINGS OF OTHER OBSERVERS

It was Sörby who first drew attention to the red fluorescence in the eggshell. Zäch found that the fluorescence varied with age, but he came to the conclusion that the age of the egg could not be definitely decided thereby. Such factors as sunlight and ultraviolet light exert an influence in the matter. Wehner found that eggs under 4 weeks old could be clearly distinguished; for those between 3½ weeks and 3½ months old it was more difficult; while eggs more than 4 months old could be classified. He found the method excellent. Gaggermeyer examined 2,500 eggs and arrived at the conclusion that eggs under 10 days old show red fluorescence. In the first days he noticed some eggs with blue fluorescence and states that they were probably deficient in hematoporphyrin. He holds that the main stress must be laid on the intensity of the fluorescence, not on the color.

Wundram came to the same result. An egg that is more than 10 days old can be distinguished from a fresh egg. Nevertheless he does not recommend the method. After 10 days the eggs are bluish-violet and after 14 to 16 days, blue.

Molanus thinks that with practice one can determine the age. V. Oyen believes that the mucous coating on the shell disappears, and then the calcareous shell itself shows blue luminance. Cold-stored eggs are difficult to classify in this manner, and must be re-tested.

Wundram found that cold-storage eggs lost color on one side, but retained it when they had been placed in the refrigerator.

Braunsdorff and Reidemeister distinguish between four different colors. They find the method unreliable. Eggs more than 10 days old may be red, and among washed and chilled eggs there are also differences. From the literature otherwise we shall merely mention that Baestle (cited from Grossfeld) has found that *the fluorescence is dependent on the eggs being bleached in daylight.*

TESTS UNDER VARIOUS CONDITIONS

Very early in our investigations we found that the method was unserviceable for determination of age and quality. On going through a large number of eggs with translumination, examination in ultraviolet rays and at the same time investigating the contents of the egg we did not obtain concordant results. An absolutely third-class egg was of reddish color, while a high-quality egg was blue or showed faint fluorescence. The same was the case with cold-stored eggs. Meanwhile, as the method is constantly being mentioned in the literature, as late as in 1937, it may be of some interest to report the following observations on eggs examined under different conditions.

Fresh eggs.—First, a close examination of new-laid eggs was made with quartz-lamp analysis. The great majority showed bright red fluorescence, with somewhat varying luminescence. One thin-shelled egg was mostly blue, with some few luminescent patches, the inside of the shell being more reddish. Bright red luminescent eggs showed a somewhat fainter color on the inside of the shell. The membrane of the shell was pale blue. Eggs taken out of the oviduct showed a very fine yellow-red color. The inside was more pinkish. The membrane was pale pink. Brown-shelled eggs proved to be very strongly luminescent.

Storage in daylight.—Six new-laid, bright red eggs were placed in a frame in the sun. After 2 days the illuminated upper part was blue, with a ring, while the lower portion was red. After 5 days the red color in the lower part had faded somewhat. After 27 days the eggs were entirely blue and somewhat dull, but not without fluorescence.

Of 4 eggs of bright red color one was placed in the sun and 3 in the shade. After 1 hour the egg placed in the sun was entirely blue, but after a longer time there was little difference between the effects of sun and shade.

Four and eight eggs were kept in daylight for about 4 months and were then almost white, *without fluorescence.* Scraping of the shell revealed a blue color.

Storage in darkness.—In darkroom: 12 new-laid eggs of red color showed no marked changes on inspection after 2, 5, and 27 days.

Storage in daylight in packing impervious to light.—Unchanged after 27 days, likewise after 38 days, and even after 4 months. After 5 months the eggs were still red, but the color had faded somewhat; they were a little dulled. One of the eggs had dried up, but was still red. The inside of the shell was of a darker red than the exterior.

Blue eggs kept in the same manner were still bright blue after storage for a long time. The inside was red.

Storage in daylight with some parts covered.—On covering some portions of the shell it was found that the lighted parts became blue in a short time, while the covered areas retained their color entirely. (See figure 1.) The boundary between night and day was quite sharp. Color-contrast could be attained in quite golden-red and deep blue.

Electric light.—The eggs were placed in a frame of light with mirror. After 30 minutes there was a perceptible difference, which became quite distinct after 1 to 3 hours.

Mountain sunshine.—The difference was distinctly evident after 1 minute.

In thermostat.—No particular change in the red fluorescence was detected after 1, 3, 7, and 15 days. One egg which was infected was found to be unchanged after 48 hours.

Eggs from incubator.—Even these eggs may have the appearance of quite new-laid eggs—strong red fluorescence.

Different parts of the shell.—After scraping with glass or with a grindstone the strong red fluorescence applies only to the outer surface, the interior surface showing dark blue fluorescence. Eggs which are white and have quite lost their fluorescence show, when scraped, exactly the same blue color in the deeper parts of the shell.

From these experiments it appears:

1. With respect to fluorescence the shell is as sensitive to light as a photographic plate. This applies chiefly to the color, but also in some degree to the intensity thereof. Electric light also has an influence on the fluorescence.

2. The color may change over to blue in the course of a few minutes in the sun and persist for months, or even up to 2 years in the dark. Storage in thermostat, and bacterial activity seem to have no particular importance.

3. New-laid eggs show the following kinds of fluorescence in the shell: Exterior surface red, interior also red, but the deeper parts of the shell show a dark blue color when scraped. The blue coloring is seen on scraping greatly bleached eggs which have lost fluorescence.

4. The fluorescence disappears almost totally on keeping for a long time in light, but this applies only to the surface, not to the deeper layers of the shell.

5. The influence of light can best be stated by covering a part of the egg and by the figures formed on the shell.

6. The inner surface of the shell has at first a somewhat lighter shade of red, but according as changes arise on the exterior the inside retains more of the original color.

7. After year-long storage in the dark, the

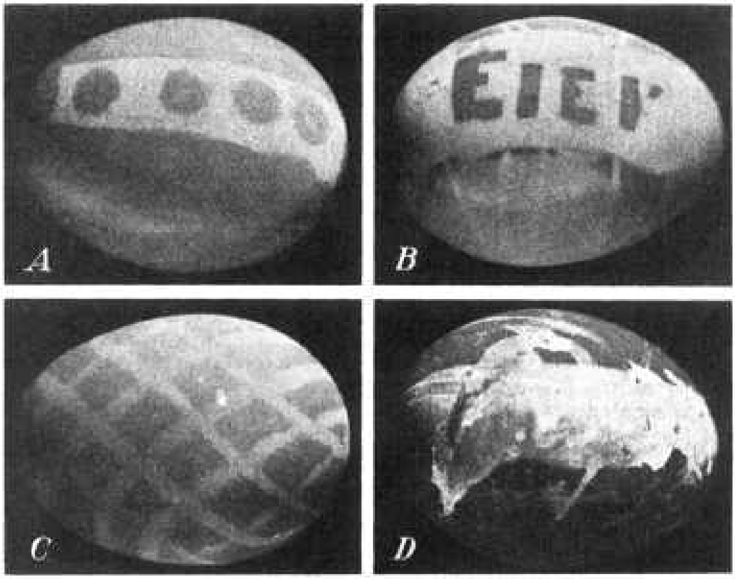

FIGURE 1.—Photograph of eggs in fluorescent light. The eggs were white in daylight. *A*, *B*, and *C* show patterns. *D* shows spots on the shell.

fluorescence declines somewhat, but the egg may be faintly red after 2 years' storage. *The color of the fluorescence and, within reasonable limits, its intensity are independent of the age and quality of the egg, but give an indication as to whether it has been stored in light or in darkness.*

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OPERATING PROBLEMS AND THE SCIENTIFIC APPROACH TO THEIR SOLUTION

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When we look around at the display exhibited here of one of the greatest sections of agriculture, it may seem a little incongrous for me to say that there could possibly be anything about the poultry industry that is not known. However, for the first time in the history of the Congresses a scientific section with five days of meetings is being devoted to *poultry products*. This fact alone, I believe, warrants devoting a period of our session to considering the importance of correlating a research program in poultry products with industry needs and to naming some of the more insistent needs of our industry that might be answered by research. It also brings before us, very vividly, the idea that there may be some things concerning the poultry industry about which we have no definite knowledge. This discourse relates to poultry that has been processed for meat purposes and the by.products obtained therefrom.

A demand for more scientific knowledge regarding poultry products has rapidly risen during the last few years. The application of science to the poultry industry is not only governed by considerations of commercial expediency, but it is also influenced by the immediate conditions of the industry and its future prospects. In the applied sciences, it is almost the rule that theory lags far behind experiment. Immediate conditions confronting the processing of poultry have often made it necessary to experiment without theory. There were no facts by which to be guided. The future prospects of this industry depend upon knowledge of our product based on facts obtained by scientific research.

There is a definite need for the accumulation of fundamental data regarding the progressive changes in the chemical composition of chicken during growth, processing, and storage. There is also need for fundamental data regarding physical and microbiological changes that take place during these periods.

The poultry industry is young. Within the memory of men now living it has grown from a back-yard side line to a vigorously organized business. Sometimes we wonder whether there is another business so important to mankind about which so little is definitely known. We have been lucky. We have trusted that the gods would be kind to us and that everything would turn out all right.

It is not necessary to go into all the details concerning poultry as a food product. But, as a food product, poultry has to compete with other foods in appearance, flavor, and all the other factors that go to make up a high quality product. Flavor, undoubtedly, receives more space in advertising foods than any other factor—and justly so, for what food enjoys a large consumption unless its flavor is pleasing? A major part of our work in processing poultry centers in the maintenance of the delicate flavor already present, with a view to improving it, if possible.

PROBLEMS OF THE FATS

It is well known that when fat is well laid on and well distributed throughout muscle tissue meat has a finer flavor—sometimes. I say "sometimes," because it is possible to have several birds from the same breed, apparently evenly fleshed with approximately the same amount of fat well distributed, that carry varying degrees of flavor. Some have almost no flavor at all. Is the fat alone responsible for the flavor? If so, what chemical composition of fat is most desirable to produce the most palatable meat? Can we produce a fat that will withstand storage, as now used, without going through changes that produce a less desirable flavor—rancidity for example? What effect, if any, does cavity fat have upon the flavor and texture of meat? Could we get a finer product by finishing poultry on the farm than by our present feeding-station practice? Raw materials play an important part in governing the quality of a finished product. Live poultry is our raw material and we need to have a broader, scientific knowledge of the control we have over this raw material before we can expect to have a super-finished product.

PROCESSING AND STORAGE

Processing holds just as important a place in quality production as does raw materials. An inferior product can be manufactured from the best grade of raw materials by improper processing. But how much of our processing procedure is based upon scientific investigations? What knowledge do we have of the physical, chemical, and bacteriological changes that take place in poultry meat during processing? Which one of these give the highest quality product? We don't know.

What effect does time, temperature, and humidity have upon physical, chemical, and bacteriological changes of poultry during precooling prior to packing? Do we want these changes? Do we want them to occur slowly or rapidly? Does a change in pH during this period affect the flavor? Do we want rigor mortis to set in rapidly? Do we want it at all? Does rigor mortis really have any effect upon the texture, tenderness or flavor of poultry? How soon after poultry is killed should it be frozen?

"Freezer-burn" is very undesirable from the standpoint of appearance and causes heavy losses to the poultry industry each year. Is "freezer-burn" accompanied by more serious defects, such as changes in the surface fat and in the edible tissues that would impair the palatability of the product? Does the rate of freezing or thawing effect the palatibility and tenderness of poultry? Would freezing, or freezing and storing in the presence of carbon dioxide have any effect on the chemical changes or rate of these changes that might take place? What causes the darkening of bone in storage?

Some of these questions may sound superfluous but we really need to know the answers. Is it not time we determined the actual facts about this industry of ours and so put it on a sound basis as to what can and what cannot be done?

An almost miraculous change has been accomplished in the past few years in poultry marketing. I refer to eviscerated poultry. Some said it couldn't be done. But it is here and it is here to stay. It may be only a few more years before all poultry will be marketed that way.

NEW PROBLEMS PRESENTED BY EVISCERATION

With the advent of eviscerated poultry all of the previously mentioned problems plus many others will confront us. It is going to be more necessary than ever before that we have fundamental scientific data to keep us from being caught in progress-retarding currents. With both the inside and outside of the bird exposed to air and to bacterial contamination we have double-trouble awaiting us. Or have we? Perhaps the reactions that take place under eviscerated conditions may improve tenderness and flavor. Full drawn poultry, on a commercial scale, is new to us. Many difficulties have already arisen. Some of them have been overcome. Others could be more easily overcome if we had a fuller knowledge of the changes in tissue which take place with freezing, thawing, drying, aging, and other necessary conditions of handling poultry. These changes are of great importance since there is involved the question of appearance, palatability, tenderness, texture, and actual nutritional quality.

With evisceration has come the necessity for concentrated research work to make use of the byproducts. We need to know what best possible uses can be found for the feet and heads, combs and wattles, fats and oil glands, endocrines and other glands, intestines, and (as we have always had with dressed poultry), blood and feathers.

The hog packing industry brags about the fact that all they lose is the "squeal." Our industry is larger than the hog industry. Can we do as well as they have in utilizing all the parts of our product?

The intent of the foregoing suggestions is to be provocative, that they may generate other ideas that will lead to a goal of increased scientific knowledge about our industry. We have gone along depending upon experience or observation alone, without due regard to science and theory. It should be remembered that though our knowledge of the way in which science can affect the art of preparing poultry products has been greatly extended in recent years, there is a vast field still to be explored and charted.

SUMMARY

A demand for more scientific knowledge regarding poultry products has rapidly risen during the last few years. The application of science to the poultry industry is not only governed by considerations of commercial expediency but also influenced by the immediate conditions of the industry and its future prospects. Immediate conditions confronting the processing of poultry have often made it necessary to experiment without theory. There were no facts by which to be guided. The future prospects of this industry depend upon knowledge of our product based on facts obtained by scientific research.

There is a definite need for the accumulation of fundamental data regarding the progressive changes in the chemical composition of chicken during growth, processing, and storage. To what extent can fat distribution, quality of fat and flavor be controlled by feeding practices? What effect does time, temperature, and humidity have on the chemical changes that take place in poultry while precooling for packing, prior to freezing,

and during the cold storage period? Are the chemical changes during this period desirable? Is freezer burn accompanied by more serious defects such as changes in the surface fat and in the edible tissues that would impair the palatability of the product? Does the rate of freezing or thawing affect the palatability and tenderness of poultry?

With the advent of eviscerated poultry some of these questions may be of more importance than in dressed poultry. Evisceration has produced more byproducts for which there is an urgent need of an outlet.

It should be remembered that, though our knowledge of the way in which sciences can affect the art of handling poultry products has been greatly extended in recent years, there is a vast field still to be explored and charted.

EFFECT OF DRAWING BEFORE FREEZING ON THE PALATABILITY OF POULTRY

By BELLE LOWE, *Iowa State College, Ames, Iowa, U. S. A.*

The investigation here reported was carried out during 1937–38 as part of the present series of studies at Iowa State College on the palatability of poultry initiated in 1935. Its purpose was to determine the effect of drawing and not drawing before freezing on palatability.

EXPERIMENTAL DESIGNS

Birds of two breeds were used, 56 Buff Orpingtons and 56 White Rocks. One breed of birds was prepared as a complete duplicate of the other and each could have been used as a separate experiment. The birds were prepared under the direction of Dr. George Stewart and were furnished by the Omaha Cold Storage Company, of Omaha. The laboratory work was done by Katherine Hoffman. The experimental plan was designed with the aid of the statistics laboratory at Iowa State College. The data to be obtained were the results of: (1) Chilling the carcasses overnight before freezing compared with freezing within 2 hours after killing and (2) drawing before freezing compared with drawing after freezing. There were 8 treatments, 7 birds in each treatment. Half of the birds were frozen within 2 hours after killing, and half were chilled overnight before freezing. Each half was divided into four groups, one of which was drawn before freezing, whereas the others were drawn at the end of 10, 30, and 90 days storage.

Since all birds were kept frozen at Omaha until the 90-day storage period for groups 4 and 8 was completed, two kinds of storage were involved (a) that of the treatments (0, 10, 30, and 90 days of storage before drawing and refreezing) and (b) the storage period at Ames, until the last chickens were cooked.

Two birds were cooked each day. Birds from each of the 8 treatments were paired with every other treatment, four days being required to cook these 8 birds. These 8 birds constituted a block, and the effect of the second storage period at Ames could be determined by block differences. Basically this plan was a randomized block, that is a block consisting of fairly homogeneous experimental material containing the same number in the block as the number of treatments. The blocks are replicated making possible an error term.

PROCEDURE

Each bird was basted with butterfat, and cooked in an uncovered pan, oven temperature 300° F., until the interior temperature of the thigh reached 190° F. The following data were recorded. The odor, fatness, condition of the skin, condition of the flesh, and color of the uncooked bird were observed and rated or scored, seven degrees of differentiation being used. A sample (about 10 grams of skin and muscle) was taken from the leg just before cooking and the flesh used for pH determination.

The aroma and appearance of each bird was scored after cooking by the person who prepared and cooked the birds. The pan drippings were poured into a graduated cylinder so that the proportion of fat to liquid could be determined. In addition the juices collecting in the body cavity during cooking were poured into a separate graduated cylinder, the proportion of fat and liquid thus being determined and recorded. It was thought that the fat collecting within the body cavity was a better indication of the fatness of the bird than the pan drippings because the latter contained basting fat also.

After cooking, the birds were divided into halves and certain muscles removed from the breast and thigh for scoring and mechanical shearing tests. From the breast muscles, the *major pectoralis* was used for scoring, the *pectoralis secundus* for mechanical shearing and the tip of the *pectoralis* for the pH determination of the cooked meat. The outer flat massive muscle of the thigh, the *gluteus primus*, was used for scoring, and the *extensor femoris*, the round muscle surrounding the thigh was used for shearing.

In order to test their efficiency, the judges were given duplicate samples of each muscle used for scoring, each judge receiving a sample from the right side and a duplicate from the left side of the same bird. Whereas the judges did not know at first that this was being done, they soon guessed that this was the procedure.

The apparatus used for the shearing tests was a modification of the Warner-Bratzler shear, the blades being of the same design and thickness as those judged most efficient by Bratzler. Muscles from both the right and the left sides were sheared to determine whether they varied in tenderness. Tracings were kept of each muscle for a record of variation in size and peculiarities. Incidentally, similar muscles from the right and the left sides were not always the same size.

The pH determinations were made by means of

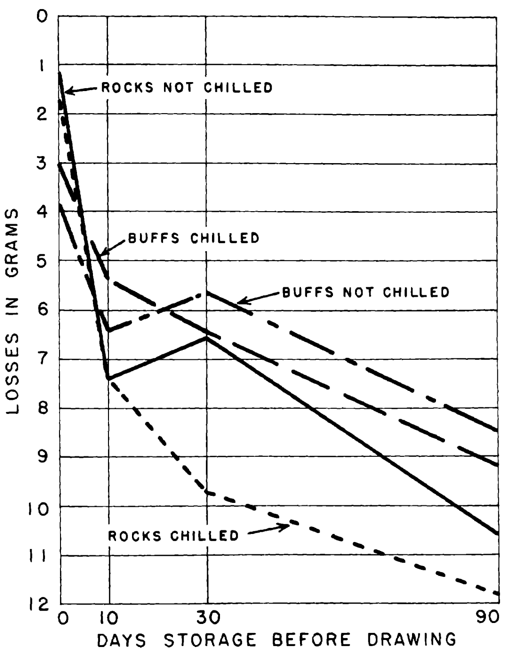

FIGURE 1.—Loss in weight during defrosting. Losses increased as the storage period increased. Birds chilled overnight lost somewhat more than those that were frozen within two hours after killing.

a glass electrode on a Coleman Electrometer, Style 200.

Analysis of variance of the uncooked weights of the Buff Orpingtons showed that larger and smaller birds were about equally distributed in each of the 8 treatments.

RESULTS

Loss during defrosting

The loss during defrosting, which includes drip and vapor is shown in figure 1. This loss increased with increased period of storage before drawing. The color of the drip varied from a deep red to an almost colorless fluid. Only a few of the birds lost excessively during defrosting.

Firmness of muscles

Lack of firmness, that is, a limpness, a loss of elasticity of the flesh and inability to spring back after touching, a general lack of muscle tone, was considered undesirable. The scores for differences in firmness of flesh were highly significant for the various treatments for both breeds of birds. The average scores are given in table 1, a score of 5 being moderately firm.

The scores, in general, show a progressive decline in firmness with increased length of storage before drawing. A comparison of the means for firmness and the mean weight lost during defrosting shows that in general as the storage period before drawing increases the flesh of the bird becomes less firm and the loss as drip increases.

Aroma before cooking

In most cases, no odor was noticeable in the uncooked birds until the nose was almost against the skin of the bird. The scores recorded were for the odor outside the body. The odor for the internal cavity was more pronounced and in some

TABLE 1.—*Mean scores for firmness of muscles given birds after defrosting*

Breed	Birds frozen within 2 hours after killing				Birds chilled overnight before freezing			
	Storage period before defrosting for drawing—				Storage period before defrosting for drawing—			
	None	10 days	30 days	90 days	None	10 days	30 days	90 days
	Score	*Score*	*Score*	*Score*	*Score*	*Score*	*Score*	*Score*
Buff	4.7	3.1	2.6	3.4	4.6	3.7	3.1	2.6
Rock	4.1	3.6	3.4	2.6	4.8	3.7	3.1	2.7

A score of 5.0 is given for moderately firm muscles.

cases slightly sour or slightly gutty. It was always more noticeable if the bird was moist. There were significant differences in the scores for desirability of the odor of the Buffs and highly significant differences for the Rocks before cooking, the odor being, in general, less desirable with longer storage periods before drawing.

Cooking losses

Cooking losses did not vary with the different treatments.

TOTAL SCORES

Palatability scores

The total palatability scores tabulated consisted of the scores of the four judges for the four samples (2 from the thigh and 2 from the breast) from each bird and were the sum of the scores for desirability of aroma and of flavor plus those for tenderness and juiciness. Although scores were given for intensity of aroma and flavor they were not included in the total scores, as it was thought more weight was attached to desirability than intensity. The analysis of variance of total scores showed no significant differences among the 8 treatments for either the Buff Orpingtons or the White Rocks.

In addition, the data were broken down to separate the effect of length of storage before drawing and the effect of chilling overnight upon the total scores. The effect of chilling was almost negligible for both breeds of birds. The effect of length of storage before drawing (0, 10, 30, and 90 days) was nonsignificant for the Buffs and although not significant for the Rocks the differences in scores for length of period before drawing were great enough to lack only a little of being

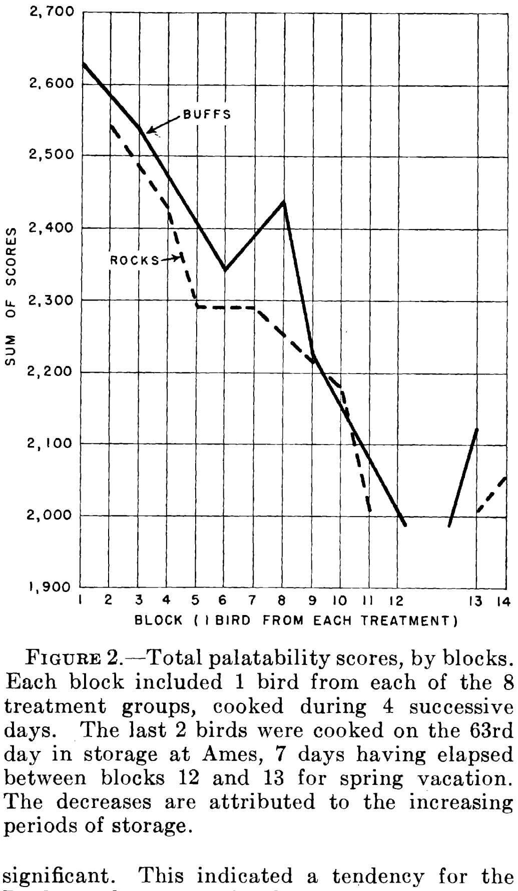

FIGURE 2.—Total palatability scores, by blocks. Each block included 1 bird from each of the 8 treatment groups, cooked during 4 successive days. The last 2 birds were cooked on the 63rd day in storage at Ames, 7 days having elapsed between blocks 12 and 13 for spring vacation. The decreases are attributed to the increasing periods of storage.

significant. This indicated a tendency for the Rocks to be less desirable with longer storage before drawing.

However, the analysis of variance of the total scores for the block differences, which would show differences caused by storage at Ames during the cooking tests, were highly significant for both Buffs and Rocks. An examination of the total scores, figure 2, shows that, in general, the trend is downward with each succeeding block for each breed. The last blocks for each breed show a slight rise. There was an interval of 7 days (spring vacation) between the cooking of blocks 12 and blocks 13 and 14.

Three possible explanations may be offered for the downward trend of these total scores:

1. The chickens deteriorated in quality while in storage at $-20°$ F. in Ames, hence the scores indicate less desirable flavor, aroma, and juiciness.

2. The judges tired of chicken since they scored it every day (Sundays included). They thus tended to give the chickens of approximately the same palatability slightly lower scores the more chicken they graded.

3. A combination of both these factors.

The first birds were cooked January 20, the last ones March 31, an interval of 63 days. Adding the days of storage at Omaha, the first birds cooked had been stored over 90 days, the last ones over 150 days.

It seems probable that a combination of the two explanations affected the downward trend of the scores. That the judges grew tired of tasting chicken and that this gave a slight downward trend to the scores is supported by the fact that after a respite of 7 days during spring vacation the scores were slightly higher than for the blocks scored just before spring vacation. That the chickens had deteriorated in storage is supported by the fact that the scores for blocks 13 and 14 are far below the scores for the initial blocks of each breed.

Flavor scores

The flavor score comprised a part of the total score and in general, both are in agreement.

The question of greatest importance in this study was to determine the effect of freezing chickens without eviscerating on the resulting flavor of the flesh. Would the muscles develop undesirable gutty odors with increase in storage time before eviscerating? If so, would it be more pronounced in the thigh or breast muscles?

It was poor planning that only outer muscles of the breast and thigh were scored. However, from the analysis of flavor scores, it could not be concluded that there were significant differences in either breed of birds because of the 8 treatments, although scores for the White Rocks did show significant differences for the breast muscles but none for the thigh muscles.

Again, the scores for the blocks showed that the differences were highly significant for both the breast and thigh muscles for both breeds of chickens, from which it is concluded that the birds deteriorated in flavor during the 63-day storage period at Ames.

The comments of the judges indicated two kinds of undesirable flavor: One was the development of a foreign or "off" flavor, the other the loss of or lack of flavor. The latter was sometimes accompanied by a peculiar texture variously referred to as woody, sawdusty, powdery, and, if the fibers were more juicy, as pasty or gummy. Since these flavors as well as the normal chicken flavor were present in some chickens of each block, it might have been related to the characteristics of the individual bird. In this case freezing might affect the texture of different birds in various ways and in defrosting the water of the tissues is held more or less firmly.

Juiciness scores

Two aspects of juiciness were observed in the study. On the one hand, the meat seemed moist yet the juices were held fairly well by the fibers. On the other hand there was a great deal of moisture or fluid between the fibers yet the fibers themselves were rather hard, dry, shreddy, or stringy. If there was only a slight amount of moisture present, then the fibers appeared powdery and rather dry.

No differences were found between juiciness of the breast and of the thigh muscles for either breed with the different treatments. Neither did chilling overnight before freezing give a more juicy meat than freezing within two hours after killing. However, in general, each succeeding block has a lower juiciness score than the preceding one and the analysis of variance shows that these block differences are significant. In other words, with longer storage at Ames, the birds were scored less juicy.

Tenderness

Tenderness was tested subjectively by the judges' ratings and objectively with the shearing apparatus. The means for scores, given in table 2, are for the four judges' scores of the eight treatments, whereas the means for shearing strength are for ten tests on the *pectoralis secundus* (breast), and for five tests on the shorter *extensor femoris* (thigh). The means for scores and for shearing strength of the right and left muscles from the same breed are, in most instances, quite close.

TABLE 2.—*Means of tenderness scores and of shearing strength for Buff Orpingtons and White Rocks*

Breed	Breast		Thigh	
	Right	Left	Right	Left
	Score	*Score*	*Score*	*Score*
Buffs	5.6	5.6	5.5	5.6
Rocks	5.5	5.6	5.4	5.6
	Pounds	*Pounds*	*Pounds*	*Pounds*
Buffs	5.1	5.2	7.6	7.6
Rocks	5.4	5.4	7.7	7.9

SCORES

Effect of treatments on tenderness

The analysis of variance of scores for tenderness showed only one significant difference among the different treatments for the Buffs. The means were erratic and typical of sampling variations, so that the one chance significance for the right breast muscles of the Buffs need hardly invalidate the conclusion of the judges that there are no significant differences in tenderness of the muscles of the Buff Orpingtons because of storing 0, 10, 30, and 90 days before drawing. However, the results with the Rocks were somewhat different. Although no significant differences for the breast muscles were found among the groups stored for varying periods before drawing, the differences for the thigh muscles were significant and highly significant for the left and right sides, respectively.

Shearing tests

For the Buffs the analysis of variance of shearing strength showed that the differences among the groups for varying periods of storage before drawing were significant for both the right and the left breast muscles but nonsignificant for the thigh muscles.

Since the tenderness scores of the judges for the Buffs and Rocks did not agree, when logically it appears that both Buffs and Rocks should respond alike to the treatments, a question of interest is how efficiently did the judges check themselves when grading the right and left muscles of the same bird? A study of these data indicated that, in general, the tenderness scores showed fairly good agreement for right and left muscles from the same bird, being less consistent for the thigh muscles for the Buff Orpingtons than for the thigh muscles of the Rocks and the breast muscles of both breeds. The judges, on the whole, were able to tell when they had two samples of the breast of the same bird or two samples of the thigh from the same bird. In some cases, the judges made note that although from flavor and other characteristics they felt sure that two pieces of breast or of thigh were from the same bird, they still gave them different scores for tenderness. The judges were not so able to tell when they had a breast and a thigh sample from the same bird but the judges were as consistent as the shearing apparatus in checking muscles from the right and left of the same bird. The shearing apparatus gave more variation for the thigh muscles than for the breast and in this respect the judges' scores for tenderness and the shearing readings were consistent.

Although the right and the left muscles from the same bird were usually about the same size, this was not always true. Hence, it is not surprising that there is sometimes shearing variation between similar muscles of the same bird.

The shearing readings showed the breast muscles to be more tender than those of the thigh in spite of the fact that the diameter of the breast muscle used for shearing was much greater than that of the thigh muscle. Everyone would agree, from organoleptic tests, that breast muscles of poultry are usually more tender than the thigh muscles.

However, before too much emphasis can be placed upon tenderness, because of the varying storage period after freezing and before drawing, the effect of defrosting and refreezing would need to be determined as well as the effect of length of storage before defrosting and freezing. The groups of birds frozen before drawing were defrosted for drawing and refrozen. The mean scores, table 3, indicate that the birds frozen a second time were somewhat more tender than those frozen only once before drawing.

Further breakdown of the data used for the analysis of variance for differences for varying storage periods, which indicated significant and highly significant differences in the left and right thigh muscles of the White Rocks, showed that the chilling overnight mean square was responsible for a greater portion of the treatment differences than the varying storage period before drawing. Hence, it cannot be validly concluded that the length of the storage periods before drawing affected the tenderness of the birds. The birds chilled overnight were judged more tender than those frozen within two hours after killing. The shearing tests agree with the scores.

TABLE 3.—*Average tenderness scores and shearing strength for Buff Orpingtons and White Rocks frozen before drawing and frozen after drawing*

Treatment	Buff Orpingtons		White Rocks	
	Breast	Thigh	Breast	Thigh
	Score	*Score*	*Score*	*Score*
Frozen before drawing	5.65	5.57	5.78	5.56
Frozen after drawing	5.55	5.55	5.72	5.05
	Pounds	*Pounds*	*Pounds*	*Pounds*
Frozen before drawing	5.00	7.48	5.36	7.52
Frozen after drawing	5.25	7.63	5.53	8.87

Higher scores and lower shearing strengths (pounds). The more tender muscles.

TABLE 4—*Sum of block scores for tenderness and sum of block shearing tests in pounds for Buff Orpingtons and White Rocks*

Block No.	Buff Orpingtons		Block No.	White Rocks	
	Breast	Thigh		Breast	Thigh
	Score	*Score*		*Score*	*Score*
1	385	383	2	379	355
3	388	360	4	369	369
6	366	358	5	374	371
8	368	363	7	379	348
9	375	359	10	372	324
12	312	344	11	348	331
13	337	325	14	333	325
	Pounds	*Pounds*		*Pounds*	*Pounds*
1	36.4	56.6	2	48.6	60.3
3	36.0	54.1	4	42.5	58.0
6	40.8	59.2	5	38.6	57.4
8	41.4	62.3	7	41.9	61.7
9	43.8	68.3	10	40.1	69.1
12	45.1	61.2	11	41.4	62.7
13	43.9	65.9	14	48.5	65.2

The higher scores and the lower number of pounds indicate tenderest muscles.

The analysis of variance of block differences indicates these differences in tenderness scores were significant for the right breast muscles of the Buffs and for the right breast and thigh muscles of the Rocks. The differences were highly significant for the left breast muscles of the Buffs. It should be noted that for the thigh muscles of the Buffs and the left thigh muscles of the Rocks the differences were nonsignificant. None of the shearing tests showed differences by blocks. Because of these variations it cannot be definitely stated that the birds became less tender with longer storage above the initial 90 days storage.

HISTOLOGICAL EXAMINATION

It would be granted that the tenderness of the same muscle from different birds may vary. It is also possible that individual birds might react differently to storage conditions and that the enzyme action might be greater in some birds than in others under the same storage conditions. Attention has been called to the fact that the flesh of some birds from each of the eight groups became powdery, somewhat like sawdust, the muscles being scored very tender though the fibers appeared quite dry and flavorless. That individual birds do react differently to storage conditions can be shown by means of histological slides. Sections were prepared from uncooked and cooked muscles, different stains being used to stain the muscle fibers, the white connective tissue or collagen, and the yellow connective tissue or elastin.

The elastin, stained with a modification of Weigert's elastin tissue stain, shows green or blue green. The collagen is red, stained with Van Giesen's mixture of picric acid and acid fuchsin, the same stain leaving the muscle fibers yellow.

In a cross section of uncooked muscle, the collagen, elastin, and bundles of muscle fibers all show clearly.

In a cross section of cooked muscle from a bird that sliced well and was palatable, the collagen, though still holding the bundles of muscle fibers together is altered by cooking, so that it no longer stains red. It will be recalled that collagen when heated sufficiently in the presence of moisture is changed to gelatin, the gelatin being soluble at high temperatures. On the other hand, elastin is not affected by heat and still takes the stain.

In a longitudinal section of cooked chicken muscle from a bird the meat of which was described as powdery, the collagen had mostly disappeared and the elastin rods were separated. Evidently, in this chicken enzyme action during storage was greater than in those birds whose meat sliced well; and the collagen was changed sufficiently so that cooking completed its change, there being only a small portion of granular collagen remaining. That part of the collagen was affected before cooking was borne out by the fact that the uncooked muscle fibers were somewhat powdery and very tender.

SUMMARY

Buff Orpington and White Rock "roasters" of uniform size, 56 of each breed, were divided into two groups each, one half being frozen within 2 hours after killing, the other half chilled overnight before freezing. Each of these groups was in turn divided into four groups: The first group was drawn before freezing; the other three groups were defrosted and drawn 10, 30, and 90 days after freezing and then refrozen. Each bird was cooked and scored thereafter. Analysis of variance was applied to observed measures.

In general, the losses during defrosting progressively increased with longer storage before drawing, the firmness of the muscles after defrosting being inversely related to the defrosting losses, the muscles being less firm with longer storage before drawing.

Neither total scores, flavor scores, or juiciness scores were affected by the length of storage before drawing nor by chilling overnight. There was an interval of 63 days between the cooking of the first and the last birds. During this 63-day period, the total, juiciness, and flavor scores gradually declined, as shown by block differences.

Tenderness as determined by both scores and shearing was not affected by the length of the period before drawing, but the birds chilled overnight were more tender than those frozen within 2 hours after killing. The shearing strength in pounds showed no block differences or, in other words, tenderness did not increase or decrease during the 63-day storage period at Ames. The tenderness scores showed a decrease in tenderness for five out of eight of the groups of muscles scored. But, before too much emphasis is put on this last result the effect of refreezing should be eliminated. There was a tendency for the muscles of some birds of all groups to become powdery, dry, and very tender during storage. It is suggested that enzyme action is responsible for this effect.

PROBLEMS ARISING DURING HOLDING OF POULTRY PRIOR TO EVISCERATION AND FREEZING

By JOHN T. R. NICKERSON *and* GERALD A. FITZGERALD, *The Birdseye Laboratories, Boston, Massachusetts, U. S. A.*

It should be stated at the outset that this paper deals primarily with the holding of poultry under refrigeration, but unfrozen, prior to evisceration and freezing.

Little work, reported in literature in connection with the subject of holding chickens refrigerated and unfrozen, has come to the attention of the authors. Several articles, however, should be mentioned since they have some bearing on this investigation.

Pennington (*3*) stated that eviscerated poultry, held under refrigeration but unfrozen, decomposed much more quickly than birds under similar conditions in the undrawn state.

Greene (*1*) found that the decomposition of the entrails of chicken had progressed in a period of 8 or 10 hours to such a degree that resulting off flavors in the meat are readily detected by the average person. The temperature of holding was not given.

Sair and Cook (*4*) showed that tainting substances do develop in the viscera of chickens during slow freezing, precooling prior to freezing, and during storage in the unfrozen state. They noted, however, that poultry stored at 32° F. for 6 days, or even longer, is generally considered of good eating quality.

The purpose of this investigation was to determine the various changes which take place in uneviscerated chickens when held under refrigeration prior to freezing and to establish conditions of handling most favorable from the standpoint of edibility.

An attempt was also made to determine some of the principal problems of the poultry packing industry, carry out preliminary experiments, and consider methods of further investigating their most important aspects.

GALL STAINS

It had been noticed that the tissues of a small percentage of chickens held undrawn, under refrigeration, for short periods of time, became stained with gall. This was apparently due to an infiltration of gall from the gall bladder and occurred only in those cases in which the gall bladder was in such a position as to lie against the flesh.

As a rule gall stains involved only those tissues lying directly against the gall bladder, but in some cases this material diffused through the flesh directly under the skin so that it could be seen through the skin of the bird before it was drawn.

Several chickens having gall stains on the internal fleshy tissues were cooked and tested for off flavors. It was evident that:

1. The portion stained with gall was very bitter.
2. The flesh contiguous to the stained portion was not bitter.

3. The greater part of the bitter portion could be removed by cutting out the innermost layer of stained flesh before cooking.

KIDNEY ODOR

Workers in the trade describe the odor of certain drawn birds as a "kidney odor." Thinking that this might indicate that such birds had been held under unsuitable conditions of refrigeration several chickens of this type were cooked and tested.

No off flavor could be determined in any area of birds described as having a "kidney odor."

WAX

Small particles of wax are sometimes left on the skin of chickens after dressing operations have been completed. Since certain types of wax harden and break into fine particles while still adhering to the skin, it is difficult to remove them during the various cleansing procedures at the eviscerating plant. In order to determine whether wax left on the skin in small and in large quantities might be the cause of unnatural flavors, several birds having various amounts of wax on the skin were cooked and eaten. It was concluded that large amounts of wax cause the skin to have a definitely bitter taste. The presence of small amounts of wax on the skin had no noticeable effect on flavor.

GREEN STRUCK CHICKENS

One of the most perplexing enigmas of the poultry packing industry is the occurrence of green vents in chickens. Such birds are usually designated as "green struck." While there seems to be no doubt that the development of green vents in poultry is due to the holding of undrawn birds under improper conditions of refrigeration, the actual cause of the green coloration has not been demonstrated.

In order to ascertain whether green struck chickens were of good flavor, six birds of this type were cooked and tested organoleptically.

TABLE 1.—*Flavor of green struck chickens*

Bird	Breast	Hip region	Area near kidney
1	Lacking in flavor	Strong	Decomposed flavor
2	Fair	No off flavor	Slightly decomposed
3	Fair	No off flavor	Slightly decomposed
4	Lacking in flavor	Strong	Decomposed flavor
5	Lacking in flavor	Strong	Decomposed flavor
6	Lacking in flavor	Strong	Decomposed flavor

It was concluded, according to the results given above, that green struck chickens usually include disagreeable flavors after cooking in the region of the hip, the region of the kidney, or both, and, moreover, that birds of such condition are likely to be lacking in flavor in those areas which are not unpalatable.

When the chickens listed in table 1 were prepared before cooking they were drawn aseptically and bacteria counts were made to determine whether the tissues had been invaded by organisms which might cause off flavors.

BACTERIA COUNTS ON CHICKENS DRAWN ASEPTICALLY

Eight types of media were used in making bacteria counts, namely, nutrient broth, nutrient agar, nutrient broth containing 0.05 percent of dextrose, nutrient agar containing 0.05 percent of dextrose, chicken broth, chicken agar, chicken broth containing 0.05 percent of dextrose, and chicken agar containing 0.05 percent of dextrose.

TABLE 2.—*Aerobic counts on peritoneal and muscle tissues of chickens: Agar cultures, bacteria count*

Chicken Number	Chicken agar		Chicken agar and dextrose		Nutrient agar		Nutrient agar and dextrose	
	Peritoneal	Muscle	Peritoneal	Muscle	Peritoneal	Muscle	Peritoneal	Muscle
	Incubated at 37° C. for 48 hours							
1	970	98	850	91	1,090	82	1,150	76
	1,060	72	960	87	1,110	70	1,090	59
2	0	0	10	10	0	0	0	0
	[1]10	0	30	0	0	0	0	0
3	0	0	10	0	0	0	0	3
	0	0	0	0	0	3	0	0
4	101	104	94	66	98	43	116	99
	98	195	94	51	92	43	104	108
5	102	42	94	0	108	75	76	10
	122	36	99	60	99	79	84	60
6	97	44	104	0	100	0	74	0
	82	41	106	0	98	10	81	0
	Incubated at 37° C. for 96 hours							
1	740	62	850	54	790	41	672	64
	780	48	910	61	840	39	650	72
2	6	6	0	0	0	0	0	7
	1	4	0	0	0	0	0	8
3	0	0	1	0	0	0	0	0
	0	0	0	0	1	0	0	1
4	192	43	180	38	144	42	160	55
	179	52	176	41	132	47	152	61
5	21	98	14	77	42	64	31	78
	16	71	11	86	40	82	26	84
6	22	6	21	18	16	0	18	14
	41	7	21	11	11	2	24	22

[1] Such small counts probably represent contamination in 1/10 dilution plates.

Chicken broth was prepared by boiling 1,000 grams of ground chicken meat with 1,000 cc of water for 20 minutes, filtering, treating the filtrate at a pressure of 20 pounds for 15 minutes, and again filtering. The broth was then tubed and sterilized. Chicken agar was prepared in the same manner excepting that 15 grams of agar per liter was added to the filtered chicken broth.

Tissue specimens were taken from the region of the peritoneum lying next to the intestine and from the muscles of the hip lying near the joint where the leg adjoins the body.

Cultures were incubated aerobically at 20° C., for a period of 96 hours and at 37° C., for a period of 48 hours (table 2).

It appeared possible that anaerobic bacteria might be present on the tissues lining the peritoneum or in the muscle tissues of the hip region of green struck chickens—and that such organisms might be the cause of off flavor. Anaerobic bacteria counts were, therefore, made on the tissues

TABLE 3.—*Aerobic counts on peritoneal and muscle tissues of chickens: Broth cultures, highest positive dilutions*

Chicken Number	Chicken broth		Chicken broth and dextrose		Nutrient broth		Nutrient broth and dextrose	
	Peritoneal	Muscle	Peritoneal	Muscle	Peritoneal	Muscle	Peritoneal	Muscle
Incubated at 37° C. for 48 hours								
1	$1/10^2$	1/10	$1/10^2$	1/10	$1/10^2$	$1/10^2$	$1/10^2$	1/10
2	None	None	1/10	None	None	None	None	None
3	None	None	None	None	None	None	None	None
4	$1/10^2$	$1/10^2$	$1/10^2$	1/10	$1/10^3$	1/10	$1/10^2$	$1/10^2$
5	1/10	1/10	1/10	None	1/10	1/10	1/10	$1/10^2$
6	1/10	1/10	$1/10^2$	None	$1/10^2$	None	1/10	None
Incubated at 20° C. for 96 hours								
1	$1/10^2$	$1/10^3$	$1/10^2$	1/10	$1/10^3$	1/10	$1/10^2$	1/10
2	1/10	1/10	1/10	None	None	None	None	1/10
3	None	None	None	None	None	None	None	None
4	$1/10^2$	1/10	$1/10^2$	1/10	$1/10^2$	1/10	$1/10^2$	1/10
5	1/10	1/10	1/10	1/10	1/10	1/10	1/10	1/10
6	1/10	1/10	$1/10^2$	None	$1/10^2$	None	1/10	1/10

TABLE 4.—*Anaerobic bacteria present in chicken tissues*

Chicken Number	In body cavity tissues		In muscle tissues	
	Incubated 72 hours at 20° C.	Incubated 48 hours at 37° C.	Incubated 72 hours at 20° C.	Incubated 48 hours at 37° C.
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
7	0	0	0	0
8	40	10	60	80
9	0	0	0	0
10	0	0	180	140

lining the region of the lower body cavity and on the internal muscle tissues near the hip joint of green vent chickens. Nutrient agar alone was used as a culture medium and cultures were incubated for 72 hours at 20° C., then at 37° C. for 48 hours before examinations were made (table 4). Anaerobic conditions during incubation were obtained by the powdered chromium—sulfuric acid method.

Organoleptic tests made on the chickens reported in table 4 after cooking showed that chickens 1, 7, 8, 9, and 10 had a strong flavor at the hip joint while all of these birds had a decomposed flavor in that region near the anus.

REASON OF GREEN VENT DEVELOPMENT IN CHICKENS

It appeared possible that the formation of hydrogen sulfide gas in the intestine might be the reason for green struck birds. Jensen and Urbain (*2*) have shown that certain pickled meats are sometimes turned green through the action of hydrogen sulfide, produced by bacterial action, on haemoglobin, oxygen having first reacted with this pigment.

Since it had been noticed that green vents occur much more frequently in white skinned than in yellow skinned chickens two birds were chosen for this experiment, one having a white skin, the other a yellow skin. Both of these chickens were fresh at the start of the experiment and showed no indication of green vents. A small glass tube was inserted through the anus about two inches into the intestine. Hydrogen sulfide gas was then allowed to flow into the intestine until a slight distension could be seen around the vent. This was carried out with both birds, after which they were allowed to remain at room temperature, observations being made every few minutes.

After a period of approximately 15 minutes the white skinned bird had developed a typical green vent. The yellow skinned bird required about 30 minutes before the green coloration was noticeable.

These birds were placed under refrigeration at 34° F. for 24 hours, after which they were again examined. The whole lower body was then colored a typical "green struck" color.

STABILITY TESTS ON CHICKEN FAT

Stability tests were made on chicken abdominal fat in order to estimate its storage life at 0° F., and to determine the resistance of chicken fat to oxidation as compared with other natural fats.

Fatty tissues were placed in a wide mouthed Erlenmeyer flask through which a steady flow of carbon dioxide was maintained. The flask was placed in a glycerine bath held at a temperature of 155° C. until the fat had melted away from the tissues and the water contained therein had evaporated. Twenty grams of fat were placed in each of a number of tubes and these were placed in an oil bath at 208° F. Air which had previously passed through potassium permanganate solution was bubbled through the fat at a constant rate until rancidity had developed, as detected by odor and taste.

At definite periods one tube of heated fat was removed and tested for free fatty acids and fat aldehyde values (*5*). Free fatty acid determinations were made by adding 5 grams of fat to 50 cc of neutral alcohol and titrating with N/10 sodium hydroxide.

Active oxygen determinations were also made. Twenty-five cc of chloroform-acetic acid mixture (2:3) were added to 5 grams of fat. One cc of saturated potassium iodide was added and mixed thoroughly by swirling the flash for 1 minute, 90 cc of distilled water was then added and the titration made with N/100 thiosulfate. One cc of 1 percent soluble starch solution was used as an indicator.

TABLE 5.—*Chemical determinations on chicken abdominal fats during heating in stability test determinations*

Time of heating (hours)	Peroxides milli-equivalents per kg		Refractive Index		Free acid per 100 g, as oleic		Fat aldehyde values	
	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2	No. 1	No. 2
0	0.0	0.0	1.4639	1.4640	0.186	0.111	0.14	0.09
2	.22	.14	1.4632	1.4633	.226	.187	.34	.23
4	.38	.24	1.4635	1.4629	.282	.292	.83	.84
6	.16	.24	1.4630	1.4632	.243	.281	.73	1.52
8	3.24	2.93	1.4643	1.4640	.181	.256	3.0	3.3
10	.73	1.46	1.4625	1.4634	.164	.282	5.6	6.2
12	1.26	1.43	1.4638	1.4648	.133	.194	9.1	10.11
14	.90	2.11	1.4640	1.4634	.158	.150	15.1	16.6
16	1.11	2.07	1.4623	1.4631	.113	.122	17.5	17.9
18	.62	1.42	1.4639	1.4650	.124	.124	19.5	20.12
20	1.21	2.76	1.4623	1.4636	.237	.202	13.4	15.6
22	2.31	3.55	1.4629	1.4632	.158	.208	10.6	11.1
24	2.57	3.96	1.4629	1.4631	.164	.161	9.9	10.2
26	3.12	5.65	1.4620	1.4626	.307	.307	6.3	5.9
28	9.29	11.16	1.4631	1.4630	.415	.415	2.1	4.3
30	23.57	27.41	1.4639	1.4635	.728	.654	.16	1.1
32	42.70	58.85	1.4640	1.4635	.923	.895	.13	.25

Organoleptic tests showed the fat to become slightly rancid at 22 hours and definitely rancid at 28 hours.

SUMMARY

There appears to be little doubt that green vent, or green struck chickens are caused by hydrogen sulfide gas produced in the intestines of chickens by bacterial decomposition of the material therein. While it has not been shown that hydrogen sulfide is produced in the intestine it is evident that this gas will cause chickens to become green struck. No other cause of this phenomenon appears probable and it is quite reasonable to suppose that bacterial action in the intestinal contents of chickens would give rise to hydrogen sulfide.

The appearance of green coloration in birds treated with hydrogen sulfide gas is somewhat faster in white than in yellow skinned chickens. It was noted in holding experiments, moreover, that green vents occur in white skinned, milk fed birds more often than in yellow skinned birds which had not been milk fed.

Several reasons, any of which might apply singly or in combination with others, might be suggested as the cause of the more frequent occurrence of green vents in white skinned than in yellow skinned birds.

The yellow color of the skin of certain chickens may tend to mask the green color produced by the action of hydrogen sulfide and oxygen on haemoglobin.

It is possible that the buttermilk present in milk feeds is an especially suitable medium for the production of hydrogen sulfide by bacterial action. Also, it is possible that buttermilk ordinarily contains a flora of bacteria of the sulfide-producing type.

It was noticed that the intestinal contents of milk fed birds were more liquid than those kept on dry feed before killing. The possibility, therefore, arises that liquid material, such as that given to milk fed chickens, favors greater bacterial proliferation in the intestine, hence the production of a much larger amount of hydrogen sulfide.

The authors are not certain that most birds not receiving the milk-type feed are yellow skinned or that most milk fed birds are white skinned, although that seems to be the general consensus of opinion of workers in the industry. However, one group of birds examined in holding experiments did not receive the usual milk type feed. They were fed with dry material, the intestinal contents remaining comparatively dry after slaughter and the skin remaining yellow. The yellow color was probably due to corn in the diet. Although these birds developed off flavors as did milk fed birds when held under improper refrigeration conditions, they showed little tendency to develop green vents.

Practically all green struck birds were found to be off-flavored at the hip joint, near the kidney or near the vent region. Off flavors appear to be present more often and in stronger concentration in the right side of the chicken, as viewed from the back. This is the side of the chicken against which the intestine lies after slaughter.

Off flavors occurring in the vent or kidney regions or nearby may be due to decomposition products which effuse through the intestine. On the other hand, it is possible that bacterial or digestive enzymes, escaping through the intestine, may cause a decomposition of the flesh in this area and therefore, be responsible for off flavors at this point. It has been shown that neither aerobic nor anaerobic bacteria are present in the fleshy tissues of green struck chickens in sufficient numbers to produce off flavors. In fact, bacteria have been found to be absent from fleshy tissues of off-flavored birds in a number of cases. This applies to tissues near the hip joint as well as to those near the kidney or vent.

The cause of off flavors at the hip joint would appear to be due to something other than effusion of decomposition products from the intestine, since it is quite far removed from this organ. Moreover, off flavors of this type near the hip joint quite often extend to the flesh near the knee joint.

A third alternative is that some enzyme action, the nature of which is unknown, takes place in the muscle itself, to cause the off flavor.

It is assumed that decomposition of blood in the femoral artery at the hip joint is not the cause of off flavors at the hip, since this has been tasted on numerous occasions in birds having a strong flavor at this point. In no case did the flavor of

the vein, or its contents of coagulated blood, resemble anything but that of cooked blood.

Stability tests carried out on chicken abdominal fat showed that it becomes rancid in a heating period of 28 hours or thereabouts. It is believed,

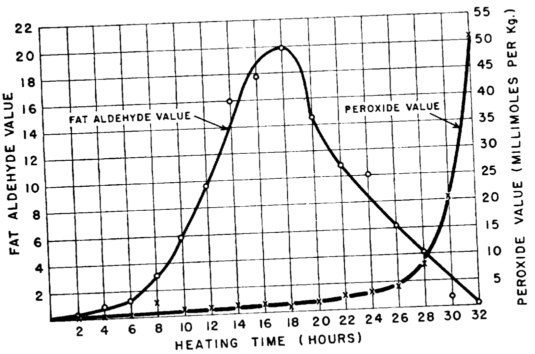

FIGURE 1.—Chemical determinations on chicken abdominal fats during heating at 208° F. while aerating.

however, that the keeping quality of chicken fat varies greatly with the individual bird. According to the tests made chicken abdominal fat should be relatively resistant to rancidity development as compared with certain other animal fats.

Active oxygen, refractive index, and free fatty acids as determined from time to time during heating showed no definite tendency to increase until the fat had become rancid. Fat aldehyde values, on the other hand, increased to a maximum before the fat became rancid and had decreased to a comparatively low value when rancidity was reached.

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EFFECT OF TIME AND TEMPERATURE OF HOLDING UNDRAWN POULTRY UPON ITS QUALITY

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Research reported in another paper on this program by the authors showed green vent and off flavor development in chickens to be governed by temperature-time conditions under which this food product was held.

Greene (*1*) reported that in the case of fowl and spring chickens visceral changes began at the end of 10 to 12 hours after being killed and that these changes were indicated by discoloration of the intestines, staining of the liver by the bile gland, and development of a gutty odor. Temperatures of holding were not given.

Sair and Cook (*2*) found that the development of taint in undrawn poultry was influenced greatly by the period during which the product was held at temperatures above freezing. They concluded that, due to the fact that taint development occurs during defrosting, there was little advantage in freezing promptly after slaughter.

Considering the facts that no literature, dealing with the effect of holding poultry for various periods at different temperatures, had come to the attention of the authors it was decided to undertake a series of researches of this nature.

AGING EXPERIMENTS

In order to investigate certain conditions existing during the period of holding poultry under refrigeration prior to evisceration and freezing, a series of experiments was inaugurated. These experiments consisted of holding birds at various temperatures for different lengths of time while testing for quality after definite periods.

Eighteen chickens were held and fed for a period of 7 days after which they were slaughtered. All birds were Leghorns. After killing they were given a semiscald and hand plucked in groups of three. Each group of three birds were then thrown into a tank of water where they remained until the internal temperature had reached 85° to 83° F. As soon as the internal temperature had reached that designated the birds were hung on racks and allowed to drain at room temperature. Seventy minutes after killing all birds were placed under refrigeration while still hanging on racks. A period of 70 minutes between killing and refrigerating was chosen because it was believed that this would simulate conditions found in most commercial dressing plants.

Chickens, handled as outlined above, were allowed to hang on racks for a period of 6 hours, after which they were packed in boxes and stored at the temperature of the refrigerated room. Examinations for quality were made immediately after packing in boxes, and, 2, 3, 4, 6, and 8 days after packing in boxes. Three birds were used for each examination.

For each temperature used, the above experiment was repeated three times, the only change consisting of a variation of the time of holding under refrigeration before packing in boxes, from 6 hours to 12, 18, and 24 hours respectively. A low temperature was used for one group of experiments and one 6° to 7° F. higher for a similar experimental series. There were, therefore, 144 birds used in holding experiments.

After removing from refrigeration chickens were tested as follows:

1. General appearance. Bloom, condition of skin, and discoloration (external and internal) were considered.

2. Bacteria counts. After removing the head and feet, birds were split down the back with a sterile knife. (In order to avoid cutting the intestine it was necessary to exercise a certain amount of caution during this operation. In those cases in which the intestine was ruptured no bacteria counts were made.) The intestines were now carefully pulled to one side and a section of flesh, 1 inch square was removed from the surface tissues near the kidney area and placed in sterile dilution water. Aseptic precautions were observed and sterile implements used in each case. A sterile metal guide was used to obtain a section of tissue 1 inch square. No attempt was made to obtain tissues of any definite depth since preliminary work had shown that few, if any, bacteria were present in the tissues lying between the surface next to the intestine and those next to the skin. Sections were always taken from the right side of the chicken as considered when looking down at the back of the bird, since the intestines seem always to lie over against this side.

3. Organoleptic tests. The entrails were removed and the intestinal fat was separated, to be used for chemical tests. The chickens were then washed thoroughly, covered with butter, slightly salted and cooked. All birds were broiled in an electric roaster in which the intensity of heat could not be varied. Since this was the case, birds were always cooked in such a manner that the distance of the cooking rack from the source of heat was constant. The time of cooking, on the other hand, was varied according to the dressed weight of the chicken in a manner which preliminary tests had shown most suitable. The following cooking times were used:

For ¾-lb. birds, 15 min. on inside, 15 min. on outerside
For 1-lb. birds, 20 min. on inside, 15 min. on outerside
For 1¼-lb. birds, 20 min. on inside, 20 min. on outerside
For 1½-lb. birds, 25 min. on inside, 20 min. on outerside
For 1¾-lb. birds, 25 min. on inside, 25 min. on outerside
For 2-lb. birds, 30 min. on inside, 25 min. on outerside

The above cooking times were not set up as proper for birds of this weight under all conditions of cooking. The time of cooking should vary with the intensity of heat and the distance of the cooking rack from the source of heat. These cooking times merely represent those found to be most suitable under the conditions of the experiment.

After cooking, all birds were tested for flavor, tenderness, texture, and off flavors by three persons. Flesh for testing was always chosen from portions under the skin which were not in direct contact with butter or salt and which had not dried out or browned due to heat.

It was found necessary to judge leg meat and breast meat separately for flavor, since a chicken might have a good flavor in the region of the breast, the leg being less flavorful or vice versa.

Scoring was done on a basis of 10 as a maximum; thus, a chicken of maximum goodness in texture, tenderness and flavor would receive a score of 10 for each.

All birds were tested for off flavors in those areas near the hip joint, near the kidney and vent portions, and near the wing joint.

Tenderness tests with the meat shear

A modified Warner-Bratzler shear, as constructed by Iowa State College was used for the purpose of supplementary tests for tenderness. The shear consisted of a blade containing an aperture, the edges of which were rounded, in which portions of flesh to be tested were placed. A block propelled by a motor moved against the sample in the aperture forcing it against the rounded edge of the blade. Resistance of the sample to the shearing action of the blade and block was registered on a milk scale attached to the blade. Portions of flesh of the same diameter and thickness were used in testing breast meat. All portions of leg meat tested were also of the same diameter and thickness. The thickness of leg meat and breast meat used for testing were not the same. Portions of each breast were tested before and after cooking. Leg meat was sampled for tenderness with the shear only after cooking and was taken from the hip region in each case.

Rancidity tests

The intestinal and abdominal fat was tried out in a wide-mouthed Erlenmeyer flask through which a steady flow of carbon dioxide was maintained. The flask was placed in a glycerine bath held at a temperature of 155° C. until the fat had been melted away from the tissues and the water evaporated.

TABLE 1.—*Results of tests made in the aging experiments*

Time held (hours) and holding room temperature (°F.)		External appearance of birds	Bacteria count[1]	Fat rancidity tests			Tenderness tests on breasts		Flavor, organoleptic[6]	Off flavored birds
				Acid value[2]	F.A.V.[3]	R.I.[4]	Shear[5]	Organoleptic[6]		
6 hrs. at	31°	Excellent	none	0.10	0.12	1.4626	......	8.2	10	none
54 hrs.	31 to 32°	Excellent	none–3,400	.22	.12	1.4624	11.33	8.9	9.8	none
78 hrs.	31 to 32°	Excellent	none–4,900	.36	.08	1.4627	5.39	10	10	none
102 hrs.	31 to 32°	Excellent	none	.46	.29	1.4627	3.65	10	9.9	none
150 hrs.	31 to 32°	Good	270–560	1.11	.32	1.4626	5.57	9.9	9.3	none
198 hrs.	31 to 33°	Good	none–2,300	.53	.37	1.4623	4.50	9.4	8.4	none
12 hrs.	31 to 32°	Excellent	none	.33	.38	1.4630	......	7.9	9.7	none
60 hrs.	31 to 32°	Excellent	none	.28	.02	1.4627	7.65	10	10	none
84 hrs.	31 to 32°	Excellent	0–4,800	.44	.06	1.4627	9.51	10	10	none
108 hrs.	31 to 32°	Excellent	none	.60	.09	1.4629	5.57	9.7	9.8	none
156 hrs.	31 to 33°	Excellent	none	.43	.17	1.4629	6.51	9.2	8.6	none
204 hrs.	31 to 33	Good	none	.83	.22	1.4634	4.28	8.7	8.4	none
18 hrs.	31°	Excellent	none	.26	.22	1.4621	7.18	8.8	8.8	none
66 hrs.	31°	Excellent	none	.36	.22	1.4629	7.47	10	10	none
90 hrs.	31°	Excellent	none	.32	.40	1.4628	5.93	9.5	9.5	none
114 hrs.	31 to 32°	Excellent	none	.58	1.3	1.4630	6.02	9.3	9.3	none
162 hrs.	31°	Excellent	none	.59	.51	1.4619	6.20	9.3	8.9	none
210 hrs.	31 to 38°	1 green str. bird 2 OK	none	.52	.75	1.4637	5.22	9.8	7.3	1, near kidney; 2 OK
24 hrs.	31°	Excellent	0–260	.23	.18	1.4635	3.66	9.7	9.9	none
72 hrs.	31°	Excellent	none	.29	.65	1.4636	5.89	10	9.9	none
96 hrs.	31°	Excellent	0–890	.59	.12	1.4629	5.41	9.8	9.9	none
120 hrs.	31 to 32°	Excellent	none	.34	.57	1.4629	4.87	9.4	9.0	none
168 hrs.	31°	Fair	none	.42	.53	1.4627	2.68	10	8.9	none
216 hrs.	31 to 38°	Fair	none	1.07	1.5	1.4614	3.53	10	7.8	none
6 hrs.	38 to 39°	Good	none	.18	.24	1.4621	6.54	8.1	9.9	none
54 hrs.	37 to 38°	Fair	0–180	.21	.06	1.4621	3.94	9.8	9.9	none
78 hrs.	38°	Fair	0–5,800	.32	.30	1.4622	3.51	9.9	9.8	none
102 hrs.	37 to 38°	Poor	0–2,350	.32	.29	1.4628	3.10	9.4	8.8	2 OK, 1 strong
150 hrs.	38 to 40°	1 green struck 2 OK	0–900	.38	1.4	1.4627	2.65	9.6	8.0	1 OK, 2 off
198 hrs.	39 to 40°	1 green struck 2 OK	none	.39	.98	1.4624	3.25	9.5	7.0	all 3 off
12 hrs.	38°	Excellent	none	.24	.26	1.4627	7.62	9.1	9.9	none
60 hrs.	37 to 38°	Good	0–16,800	.32	.29	1.4624	5.77	9.7	9.8	2 OK, 1 off
84 hrs.	37 to 38°	Good	0–560	.32	.48	1.4629	10.31	9.2	9.1	2 OK, 1 off
108 hrs.	38 to 39°	1 green str. bird 2 OK	0–440	.56	.49	1.4627	4.16	8.7	8.5	2 OK, 1 off
156 hrs.	38 to 40°	1 green str. bird 2 OK	none	.58	3.4	1.4624	6.17	9.3	7.0	3 off
204 hrs.	39 to 40°	1 green str. bird 2 OK	none	.59	1.1	1.4624	4.65	8.5	6.3	3 off
18 hrs.	36 to 37°	Excellent	none	.26	.18	1.4623	5.49	9.4	10	none
66 hrs.	37 to 39°	Good	0–7,000	.51	.81	1.4629	4.02	9.9	9.6	none
90 hrs.	36 to 37°	Poor	none	.51	.35	1.4623	5.55	9.8	8	3 off
114 hrs.	36 to 37°	Poor	none	.58	.12	1.4635	4.93	10	7.7	3 off
162 hrs.	37°	1 green str. bird 2 OK	0–840	.42	.45	1.4622	4.53	9.2	7.5	3 off
210 hrs.	37°	1 green str. bird 2 OK	none	.55	.45	1.4624	5.88	......	....	none tested
24 hrs.	36 to 37°	Excellent	0–820	.23	.81	1.4620	4.61	9.3	8.9	none
72 hrs.	36 to 37°	Good	none	.39	.07	1.4624	3.35	10	9.1	none
96 hrs.	36 to 37°	Good	0–560	.74	.36	1.4624	4.43	9.7	7.5	3 off
120 hrs.	36 to 37°	1 green str. bird 2 OK	none	.47	.33	1.4623	3.73	9.8	8.0	3 off
168 hrs.	37 to 38°	Poor	0–16,000	.52	.42	1.4625	6.64	......	....	none tested
216 hrs.	37°	Slimy skin all birds	none	.86	.55	1.4624	4.89	......	....	none tested

[1] Bacteria per square inch of flesh surface.
[2] As grams of oleic acid per 100 grams of fat.
[3] Fat aldehyde value.
[4] Refractive index.
[5] Milk scale reading; tough tissue indicated by high readings.
[6] Average of three tests made by three different people on three birds; tests made on basis of 10 as best; highest figures indicate best samples.

The decanted fat was tested for free fatty acids by titrating in neutral ethyl alcohol with N/10 sodium hydroxide. Phenolphthalein was used as an indicator.

Fat aldehyde values according to the Schibsted method (*3*) were also determined, using rosanaline hydrochloride alcohol-sulphur dioxide reagent.

Since active oxygen determinations made in preliminary investigations gave values at or near zero, no tests of this kind were made during aging experiments.

The results of the several tests are shown in table 1.

SUMMARY

Holding experiments showed that green vent development in chickens could be prevented by the use of proper refrigeration temperatures. It has been found, however, that in any group of birds held undrawn and under such conditions as to promote the development of green vents (comparatively high temperature for several days) practically all members of the group will be off flavored near the kidney, near the vent, at the hip or in all of these areas, but a comparatively small number of the group will have developed green vents. According to the results of holding experiments chickens may be killed, dressed, placed under suitable refrigeration temperature within 70 minutes after killing, and held for a period of 8 days without risk of off flavor development. However, certain organs, such as the gizzard, tend to become discolored during long periods of holding under such conditions. Undrawn chickens held refrigerated, but at only slightly higher temperatures may develop off flavors within a period of 2 to 3 days. No marked loss of flavor was detected in birds held at ordinary refrigerator temperatures for a period of 2 to 3 days even though localized off flavors had developed in some cases.

Slimy skin or skin slipping takes place in chickens only after long periods of holding at relatively high temperatures and should never occur in birds properly handled from the standpoints of refrigeration and sanitation. Off flavor development in undrawn birds occurs long before slimy skin.

Organoleptic tests showed maximum tenderness to ensue in chickens held uneviscerated at temperatures near freezing for 2 to 3 days after slaughter. Shear tests confirmed these findings in a general way. It is not meant to infer that all shear tests made were in complete agreement with organoleptic tests for such was not the case. It is believed that shear tests are of value only in those cases where a large number of tests can be made upon the specimen under investigation.

Considering the tests used to determine changes in the fat of undrawn chickens during holding periods at temperatures above freezing—peroxide values, fat aldehyde values, refractive index, and free fatty acid value—only the last showed a general tendency to increase as the holding period was lengthened.

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PRECOOLING, FREEZING AND STORAGE OF DRESSED POULTRY[1]

By W. H. Cook, *Biochemist, Food Storage and Transport Investigations, Division of Biology and Agriculture, National Research Laboratories, Ottawa, Canada*

The over-all quality of dressed poultry depends on the quality of the live bird, and also on the methods used in slaughtering, storing, and marketing the product. This paper reviews the results of certain investigations which we have made on the precooling, freezing, and frozen storage of poultry. For details the reader is referred to the original papers listed at the end of this article.

The various methods now employed for precooling and freezing poultry can be viewed from two standpoints: Those designed to promote plant efficiency or reduce processing costs without affecting the quality of the product except indirectly; and those designed to preserve or improve the quality of the product without necessarily contributing to reduced cost or improved efficiency. Improvements of either sort are beneficial to the poultry industry, and although this paper is concerned primarily with modifications that maintain or improve the quality of the final product, the necessity for commercial practicability has been recognized throughout.

PRECOOLING

It is generally accepted that poultry should be cooled to a temperature near the freezing point as quickly as possible after slaughter. Prompt and rapid precooling usually improves the over-

[1] Contribution from the Division of Biology and Agriculture, National Research Laboratories, Ottawa.

all efficiency of processing, reduces shrinkage, and inhibits the growth of organisms that cause taint and spoilage. It must be recognized, however, that certain post-mortem changes occur in the muscle tissue, and that improvement in the quality of the product might result if sufficient time were allowed for changes to occur before they are inhibited by freezing. These considerations present the following questions: What is the most rapid method of cooling poultry to a temperature near the freezing point? Do any desirable post-mortem changes occur in the muscle tissue, and if so, what period is required for them to reach a satisfactory state of completion?

Poultry may be precooled in air, or in water followed by hanging in air to allow the birds to dry off before grading and packing. The time required for cooling to say 34° F. depends on a number of factors such as the initial temperature of the bird; the temperature of the cooling medium; the size of the bird; its shape, extent and method of deposition of fat, and so forth. Of these factors only the temperatures and the size of the bird can readily be measured.

Experiments were undertaken (*1*) to determine the period required, in both air and water, for cooling poultry of different sizes, from various initial temperatures. The results are given by the following equations:

For cooling in air only:

$$T = -5.0 + 6.23 \log (tp - t_m) + 1.16\, w$$

For cooling by immersion in water for 2 hours followed by hanging in air at the same temperature:

$$T = -0.53 + 1.26 \log (tp - t_m) + 0.38\, w$$

where

T = time in hours to pass from initial temperature to 2° F. above the temperature of cooling medium

tp = initial internal product temperature in ° F.

t_m = temperature of cooling medium in ° F.

w = weight of bird in pounds.

From these equations it is evident that a 2-hour period of immersion reduces the cooling time to about half that required in air alone. The effect of temperature gradient and size of bird only accounts for about half the observed variability in the rate at which different birds can be cooled. The remaining variability is presumably contributed by unknown factors such as shape, degree of fatting, etc.

The shrinkage that occurs in air during a 24-hour cooling period varies from ¼ percent to 1 percent depending on the humidity in the room and the size of bird. Immersion in water for 2 hours, followed by hanging in air, causes a gain in weight of about ¼ percent on the average, although the gain is extremely variable. No difference between the bloom of birds cooled by the two methods could be detected during storage in the frozen state.

Turning now to the biological aspects of precooling, it is obvious that biochemical changes in the muscle are of primary importance only if the product is to be frozen, since these changes could presumably occur during storage if the birds were not frozen. In an investigation (*5*) into the amount of the fluid exuded (drip) from minced poultry muscle frozen at different rates, it was found that if the poultry meat was frozen within 3 hours after slaughter the quantity of drip was maximal and independent of the freezing rate. If the birds were precooled for 24 hours before freezing, however, the maximum quantity of drip was somewhat lower, and a typical curved relation was obtained between the quantity of drip and the freezing rate. These results suggest that some change occurs in the muscle which affects its water retaining capacity. Since the glycogen present in the muscle is changed to lactic acid after death, it was felt that changes in acidity might be the factor affecting the protein-water relations. Although measurements showed that the whole muscle changed from pH 7.0 to about 5.5 within 24 hours after slaughter, the majority of the minced tissues usually had a pH of about 5.8 to 6.0, and a relation between pH and drip with poultry meat within 24 hours after slaughter could not be demonstrated. Similar investigations on other meats (*6*), however, indicated that the quantity of drip is affected both by the period between slaughter and freezing and the pH of the tissues, and that these two factors each exert an independent action.

In conclusion, it appears that some post-mortem change occurs in poultry meat during precooling, but the nature of this change and its effect on the final eating quality cannot be stated.

FREEZING

Stored poultry is generally held in the frozen state. This immediately brings up the question of the best method of freezing the product without reducing the quality. When poultry is packed in 12-bird boxes and frozen in a so-called "sharp-freezer," the period required for freezing may vary from 15 to 60 hours, depending on the temperature, air movement, etc. in the room and the size and type of package used. Recently quick freezing has been practiced commercially by freezing individual birds, or packages, using equipment designed to accomplish freezing in from 1 to 2 hours.

Quick freezing has been shown to improve the final quality of such products as beef and fish, that exude tissue fluids, or "drip" after slow-freezing and thawing. Since slow freezing tends to produce larger crystals than quick freezing, crystal size and drip are associated in the products mentioned above. This has frequently led to the generalization that drip is dependent on the crystal size, or rate of freezing, in many products. Although quick freezing doubtless reduces the size of the crystals produced in poultry muscle, there was no direct evidence that this meat exuded tissue fluids after slow freezing.

Experiments were made (*5*) on the effect of freezing rate on drip formation using whole birds, eviscerated birds, and half birds, the last being used to insure against mechanical trapping of any exuded liquid. In none of these experiments was the amount of drip of any practical significance, regardless of whether freezing was accomplished in 1 hour (quick frozen) or 18 hours (slow frozen). It was therefore concluded that slow freezing did not cause deterioration in quality of poultry by promoting exudation of the tissue fluids on thawing.

Experiments with minced poultry muscle, however, gave some evidence of drip, and indicated that freezing did have some effect on the tissues. If this change is related to quality, then precooling for a period of a day or so before freezing is more important than the rate of freezing, since the drip is independent of the freezing rate if the birds are frozen shortly after slaughter, and it becomes dependent on the freezing rate only after precooling. Even after precooling, the tissue must be frozen in less than an hour if the drip is to be reduced to half that which occurs during slow freezing.

Certain other advantages have been claimed for quick freezing; namely, reduction in the number of bacteria; reduced development of visceral taint; and superior bloom and appearance as the result of reduced surface desiccation during freezing. These claims were therefore investigated in a preliminary way. It was found that the number of bacteria present in minced poultry meat was not significantly reduced by either quick or slow freezing. In consequence there was no evidence to indicate that quick freezing confers any advantage over slow freezing from the standpoint of bacteria numbers. Quick freezing may contribute to plant performance, however, and by avoiding delays between slaughter and freezing, the growth of organisms during this period may be reduced.

The transmission of visceral taint appears to depend primarily on the period during which the product is held at temperatures above the freezing point. The length of the precooling period between slaughter and freezing, and the rate and period over which the poultry is held between thawing and evisceration are therefore more important factors than the rate at which the actual freezing is accomplished. Nevertheless, it is difficult to assess the practical significance of these results. Poultry precooled promptly after slaughter and held for 6 days at 32° F. are normally considered quite palatable, yet more taint was transmitted under these conditions than under the ordinary conditions of precooling, slow freezing, and thawing. Obviously if any reduction in quality results from transmission of visceral taint, evisceration shortly after slaughter rather than quick freezing is the solution for this problem.

The effect of freezing rate on bloom and surface desiccation was restricted to a study of the loss of weight during freezing. The over-all loss of weight, during freezing, from poultry previously precooled to 32° F. was 0.08 percent for birds frozen in 1.5 hours in a room at $-40°$ F., and 0.12 percent for a similar lot frozen in 16 hours at $+7°$ F. In the study of precooling referred to earlier, it was mentioned that birds cooled in air lost 0.25 percent while those precooled in water gained 0.25 percent, yet these two lots of birds showed no difference in the period required for the development of freezer burn. It was therefore concluded that the slightly lower loss (0.04 percent) of moisture from the quick frozen as compared with the slow frozen birds would have little or no effect on the retention of bloom or on the development of freezer burn during storage.

It is concluded from these results that where poultry can be handled promptly and properly with respect to precooling, freezing, and storage, no advantage is to be gained by using rapid rates of freezing, as far as a direct improvement in the quality of the product is concerned. Quick freezing may improve plant practice, however, and in addition to reducing costs of operation, may contribute to the final quality of the product by reducing or avoiding delays, transfers, etc. Evisceration, on the other hand, appears to be advantageous, since it removes any possible deterioration through the transmission of visceral taint, permits more sanitary handling practices in the final stages of marketing, and avoids the necessity for thawing the product some time prior to its consumption. We have obtained no evidence to indicate that the eviscerated product is more difficult to process or store than the ordinary product, if it is handled and frozen promptly. In practice, however, quick freezing may be a beneficial adjunct to evisceration, since it should tend to reduce the detrimental effect of accelerated microbial growth on the cut surfaces prior to and during freezing.

FROZEN STORAGE

It is generally recognized that freezer burn is caused by surface drying. In consequence, the rate and extent to which freezer burn develops during storage will depend on the factors affecting the rate of drying. These factors include the temperature, humidity, and rate of movement of the atmosphere surrounding the product. Since poultry are stored in closed packages, the rate of air movement is usually small and of secondary importance compared with temperature and humidity.

Information gained from the drying of other materials shows that the rate of drying decreases with the temperature at constant relative humidity, and decreases as the humidity increases at constant temperature. These facts were confirmed for the storage of frozen poultry (*2*). Birds stored at $+7°$ F. and 94 percent relative humidity showed definite freezer burn in from 8 to 10 weeks, whereas similar birds stored at the same humidity at −7.5° F. did not show freezer burn until they had been stored 22 to 26 weeks.

Experiments designed to obtain quantitative information on the humidities and temperatures required showed that humidities of 98 percent or higher, relative to ice, were required if freezer burn was to be prevented over storage periods of 6 to 10 months at temperatures in the range of 5° to 10° F. On the other hand, at temperatures of −5° to −10° F. humidities of 96 percent or higher were sufficient to prevent freezer burn for a similar period. It can be seen from this that a 2-percent increase in relative humidity in the vicinity of saturation is as effective for reducing freezer burn as a decrease in temperature of 15° F. In drier atmospheres, unit increase in humidity becomes somewhat less effective than these results indicate. Computations based on drying equations indicate that increasing the relative humidity from 85 to 95 percent at a temperature of 10° F. would be as effective for reducing freezer burn as decreasing the temperature to −10° F. at 85 percent relative humidity. Even in these circumstances it should be more economical to prevent freezer burn by increasing the humidity in the freezer than by decreasing the storage temperature. Experiments along this line indicate that a freezer can be humidified for about about one-fifth of the cost of lowering the temperature to the same effective level from the standpoint of deterioration from surface drying.

Apart from the control of such conditions as temperature and humidity, freezer burn can be prevented by proper packaging of the product. Since the ice crystals in the product have a vapor pressure equivalent to 100 percent relative humidity, little or no evaporation from the poultry can occur if the package is moisture proof. Complete impermeability to moisture is probably impossible in a commercial package and probably unnecessary for the prevention of freezer burn over the ordinary holding periods. Experiments in which moisture-resistant liners, such as waxed paper, and moisture-impermeable liners, such as aluminium foil, were used in both the sealed and unsealed condition, showed that the moisture-resistant stocks generally provided sufficient protection, provided the folds and joints were properly sealed. On the other hand, the more costly impermeable stocks failed to protect the product unless the joints were sealed. These results indicated that attention should be given to practicable methods of sealing poultry packages rather than to experiments designed to determine the degree of moisture resistance necessary in satisfactory lining materials.

The sealing of the paper stocks used for lining wooden boxes was considered impracticable commercially, and attention was turned to the telescoping type of corrugated carton. This proved to be reasonably satisfactory if the material was suitably waterproofed, although it was found difficult to apply an effective seal to such a package. Since sealed packages are unsuitable for holding poultry in the unfrozen state, it seemed desirable to design a package that could be both ventilated or sealed. This led to the use of the lower section of the telescoping box, enclosed in two similar members of half the depth which slipped over it from the top and bottom. The junction of the abutting edges of these cover members thus occurred on a flat surface, and could be adequately sealed with a suitable strip of adhesive. By providing openings in each end of the inner member and suitable registering creased flaps in the upper cover member, it is possible to convert the package from a ventilated to a sealed type, or vice versa, as demanded by a change of storage conditions, without opening or disturbing the original pack.

Quite apart from the development of freezer burn, the bloom on stored poultry was found (*3*) to deteriorate more rapidly under conditions that promoted drying. A high humidity or a low storage temperature was therefore necessary to preserve bloom. We have been able to preserve the original bloom on poultry stored at 8° F. for over one year by using a saturated atmosphere or adequately sealed packages. Under the somewhat drier conditions prevailing in an ordinary freezer, the bloom was found to deteriorate more rapidly on the lower commercial grades of poultry. This effect, however, was not as striking as the effect of color, yellow-fatted birds losing their bloom much more rapidly than white-fatted birds.

The results of these experiments show the need for preventing the surface drying of frozen poultry during storage, and it seems likely that this can be accomplished more economically by humidification than by the use of low storage temperatures. At this stage the question arises as to what storage temperatures are required to prevent other detrimental changes. In approaching this problem it was felt that changes in the fats would be more likely to occur and more likely to affect the eating quality than changes in the proteins. Peroxide oxygen and free fatty acid determinations (*4*) were therefore made on poultry fat after storage under various temperature conditions for varying periods. It was found that little or no change occurred in free fatty acid during storage in the frozen state. The peroxide oxygen determinations showed that poultry fat was also quite resistant to the changes causing rancidity, there being little or no evidence of even incipient rancidity in poultry held for one year at 8° F.

In poultry held for two years at various relative humidities at temperatures of 8° F. and −7.5° F., some evidence of incipient rancidity was found. The development of this condition was least at the lower temperature, and at a given temperature it occurred more slowly at high humidities The effect of humidity is presumably indirect, and reflects the extent of surface drying which exposes a greater proportion of the fat to the oxygen of the air.

It is possible that other detrimental chemical changes can occur in frozen poultry during storage, but this seems unlikely. It appears therefore that storage temperatures in the vicinity of 0° F. or even higher will be entirely satisfactory for holding poultry for periods of one year provided the freezer is humidified to approximately saturation to prevent freezer burn and preserve bloom.

SUMMARY

Equations are given relating the initial product temperature, the temperature of the cooling medium (air or water), and the weight of the bird, to the time required for cooling to any required temperature above the freezing point. The importance of certain unmeasured properties of the product, such as fat content, and shape of bird, in determining the cooling time, are demonstrated. Comparisons are also made of the relative shrinkage and subsequent retention of bloom during storage, after precooling in air and water respectively.

Minced poultry meat frozen within 3 hours of slaughter was found to exude much more fluid (drip) than poultry that had been precooled 24 hours prior to freezing. The amount of drip obtained from minced poultry muscle that was not precooled was independent of the rate of freezing. If the birds were precooled for 24 hours the drip obtained from the minced muscle decreased as the freezing rate increased.

Although these results indicated that a change occurs in the muscle during precooling, there was no evidence that whole muscle exuded drip following any rate of freezing. The rate of freezing appears to have no effect on the number of bacteria present and little, if any, effect on the subsequent extent of surface desiccation or development of visceral taint. Taint development appears to depend primarily on the period during which the product is held above the freezing point, whether this occurs during precooling, freezing, or thawing.

The principal factors causing deterioration of dressed poultry stored in the frozen state, namely, freezer burn, loss of bloom, and changes in fats, are discussed in relation to different storage conditions and methods for the prevention of these defects.

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TEMPERATURE AND HUMIDITY IN THE SHORT-TIME HOLDING OF EGGS[1]

By A. Van Wagenen,[2] *Investigator in Marketing,* G. O. Hall, *Assistant Professor of Poultry Husbandry, and* M. Altmann, *Research Assistant in Poultry Husbandry, Cornell University, Ithaca, New York, U. S. A.*

The need for information on the problem of farm handling of eggs was brought out during the course of an investigation by the Bureau of Agricultural Economics, United States Department of Agriculture, on the consumer preferences for eggs in New York City, Boston, and Philadelphia. Considerable difficulty was experienced in obtaining a supply of eggs of good quality for use in determinations of consumer preferences. The fact that there were some eggs on the market of good interior quality suggested that the problem might be one of farm handling as well as of transportation, and that an important point of attack upon the problem of securing a satisfactory supply of good-quality eggs in wholesale markets was at the farm.

The aims of the study reported here were to determine: (1) The physical changes occurring in eggs (2) the optimum temperature, the optimum humidity, and the proper routine for handling and holding eggs at the farm prior to shipment.

PRELIMINARY STUDIES

In the spring of 1932, preliminary experiments were conducted to determine the behavior of the refrigeration equipment first installed. As a

[1] This work, begun in 1932, with the Departments of Poultry Husbandry and Agricultural Engineering, New York State College of Agriculture and Servel, Inc., cooperating, was expanded in 1933 with aid from the Empire State Electric and Gas Association.

[2] Now with Department of Agricultural Economics and Farm Management.

result of these tests the original refrigerator was reconstructed to provide more accurate control of temperature and humidity and a second unit was provided. Thermostatic controls were adjusted so that the operating temperature range was within one or two degrees of the predetermined experimental temperature.

Control of the humidity in the boxes was obtained by means of water pans placed in alternate layers with trays for the eggs and recording equipment. The fan of the cooling coil provided necessary circulation of air and practically uniform conditions throughout the entire box. The quantity of ordinary tap water in the pans was varied in order to maintain a relative humidity of 85 percent. Lower humidity conditions were obtained by the use of calcium chloride and concentrated sulphuric acid solutions.

Recording instruments were used to measure temperature and relative humidity during each test run. The instruments were frequently verified by comparison with sling psychrometer readings.

METHOD OF PROCEDURE

The eggs used were from a special flock of Single-Comb White Leghorns at the Department of Poultry Husbandry. These birds were subjects of another project involving egg quality experiments and were known to produce eggs of relatively constant quality as measured by the tests here described. Eggs from these birds were not available for this experiment at all times or in large numbers. It was felt that the greater degree of standardization possible by using eggs from this flock was desirable. Eggs from this flock and their progeny were used throughout the tests except where otherwise noted.

The routine followed in all test runs was essentially uniform. Eggs from the flock of calibrated birds were marked with the bird number and date as removed from the trapnest. These eggs were then brought to the laboratory at about four o'clock on each of ten consecutive days, weighed, and placed in the refrigerator under test conditions. Each day's eggs were removed from the refrigerator at the expiration of ten days, and, together with fresh eggs from the same flock of birds, were subjected to the laboratory tests. The fresh eggs were handled in the same way as those placed in storage except for the storage period. In the case of several of the runs, eggs were saved for another ten-day period following the fresh run period, placed in storage and tested at the end of the ten-day storage. Thus two held-egg runs were compared with one run of fresh eggs. Only the eggs of those birds where three or more readings were obtained in both runs (held and fresh) were considered.

LABORATORY TECHNIQUE

The first experimental test run showed rather conclusively that candle tests for egg quality were not accurate enough for the determination of the small differences that were to be found in the short-time holding of eggs. Consequently a standardized laboratory procedure of examining the opened-out eggs was adopted. This procedure is that described by Van Wagenen and Wilgus (*6*, *7*).

MEASURES OF QUALITY

The measures of quality used and the methods of their determination have been described in detail elsewhere as cited below:

1. *Observed condition of the firm albumen* (Sharp, *4*, Van Wagenen and Wilgus, *5*, *6*). The opened egg is scored by comparison with a series of photographic standards. These grade from score 1.0, representing an egg in which the firm albumen envelope stands up well around the yolk and retains the egg shape, to score 5.0, in which no firm albumen is discernible. This score is an attempt to measure egg quality in terms of what the consumer actually sees as he breaks the egg out for use.
2. *Percentage of firm albumen* (Sharp, *4*). As used in this study, the percentage of firm albumen is similar to the measure of interior egg quality described by Holst and Almquist (*1*) and by Lorenz and Almquist (*2*), but the pipette method described by Van Wagenen and Wilgus (*5*), was used in its determination instead of the screen method described in the earlier publication. This is a measure of the amount of the firm, jelly-like albumen and is of some importance in the appearance of the broken-out egg. It is not directly correlated with the observed condition of the firm albumen.
3. *Percentage of inner thin albumen* (Sharp, *4*). That portion of the egg albumen found within the firm albumen envelope, exclusive of the chalaziferous layer. The importance of this measure is not yet definitely established.
4. *Percentage of outer thin albumen* (Sharp, *4*). That portion of the egg albumen found outside of the unruptured firm albumen envelope. When inner and outer layers of thin albumen are mixed, the mixture is known as the apparent thin albumen. The percentage of outer or apparent thin albumen is an important influence in the appearance of the opened egg.
5. *Yolk index* (Sharp, *3*). The ratio of the width of the yolk to its height as determined after resting on a plane surface for five minutes. A decrease of the yolk index from that of the new-laid egg is an indication of deterioration.
6. *The loss in weight, or evaporation.* This is important as long as size of air cell is a consideration in the determination of egg grades.

In order to determine the possible effects of jarring or rough treatment in the farm handling or transportation of eggs as indicated by the measures of quality used, an additional experiment was made. This included a series of tests on eggs shaken on a special machine after being subjected to various holding treatments. The eggs used in the "shaking" tests were from pullets of the regular Experiment Station flock of Single-Comb White Leghorns.

RESULTS AND DISCUSSION

Research on this project extended over a period of about three years. Approximately 4,800 eggs, involving 43,200 single observations were used in obtaining the data presented in the accompanying tables.

The measures and the methods used in the determination of changes in interior egg quality have been described. In the intepretation of the data in the tables which follow, it is necessary to note that an increasing or positive change in the score of the observed condition of the firm albumen indicates a decline in quality. A decrease, or a negative change, in the percentage of firm albumen similarly indicates a decline in quality. A decrease in the percentage of inner thin albumen short holding period. This may be taken to indicate that some of the inner thin albumen had been absorbed by the firm albumen and that little breakdown or thinning of the firm albumen has taken place in the short time studied. This measure, therefore, has little significance in this study except to indicate that a change has taken place within the albumen of the egg. These findings do not entirely agree with those reported by Holst and Almquist (*1*), but may possibly be explained by differences in technique. A temperature of 35° F. gave better results than any of the other holding temperatures, but a distinct disadvantage at this temperature is found in the disagreeableness in the handling of the eggs due to condensation of moisture ("sweating") on the eggs when removed from the holding unit to a warmer room. Eggs held between 45° F. and 55° F. do not "sweat" appreciably when brought into a normal room temperature of about 70° F. to 75° F. with the usual low humidity. Eggs which

TABLE 1.—*The changes in various measures of interior quality that occur during a 10-day holding period under varying conditions of temperature at a relative humidity of 85 percent*

Measure	April 1934		January 1935		January 1935		March 1935	
	Fresh	Held at 35° F.	Fresh	Held at 45° F.	Fresh	Held at 55° F.	Fresh	Held at 65° F.
	Quality	Change	Quality	Change	Quality	Change	Quality	Change
1. Condition of firm albumen	1.75	+0.22*	1.88	+0.52*	1.84	+0.86*	1.94	+0.94*
2. Percentage of firm albumen	55.38	+1.46	50.44	+1.35	50.55	+2.80	51.00	+2.80
3. Percentage of inner thin albumen	21.47	−2.05	24.41	−4.94*	24.13	−6.81*	22.35	−5.07*
4. Percentage of outer thin albumen	23.15	+0.60	25.15	+3.59	25.32	+4.00	26.65	+2.28
5. Yolk index	.415	− .003	.435	− .015*	.433	− .021*	.422	− .032*
6. Loss in weight in grams	....	.218	....	.331	....	.346	....	.378
Date of test	April 1934		January 1935		January 1935		March 1935	

* Significant—odds against so great a difference being due to chance alone greater than 100:1.

is indicative of a decline in quality and is usually accompanied by an increase in the outer thin albumen. This results in an apparently increased wateriness of the egg.

The yolk index is an indicator of the strength of the yolk (vitelline) membrane and the ability of yolk to retain its round, upstanding appearance. A decrease, or negative change in the index is indicative of a decline in the quality of the yolk.

Temperature

Table 1 shows the changes in various measures of interior egg quality that occur during a 10-day holding period under varying conditions of temperature at a relative humidity of 85 percent. It will be noted that at successively higher holding temperatures the change from the fresh quality was progressively greater. This was true for all measures of interior quality except the percentage of firm albumen. In this connection, it may be noted that in only two cases was a decline in the percentage of firm albumen observed during the were held at temperatures of 45° F. and less showed little change in quality, as determined by the measures used, during a 10-day holding period. The significance of the change from fresh quality was determined in each case by calculation of the standard error of the difference and determination of odds against such differences being due to chance. Under the conditions of the experiment, only those changes in which the odds against chance occurrence were greater than 100 to 1 were considered significant. These are indicated by an asterisk (*) in the tables.

Table 2 summarizes the results of holding eggs at a constant relative humidity of 85 percent and temperatures of 55° F. and 80° F. for 4-, 8-, and 10-day holding periods. At both temperatures condition of firm albumen, yolk index, and loss in weight changed directly with the length of the holding period. It is interesting to note that the unfavorable change in practically all measures of quality was greater in eggs held for 4 days at 80° F. than in eggs held 10 days at 55° F. This further emphasizes the importance of temperature in the preservation of egg quality. It can be stated from the information available that, for a short-time holding period (up to 10 days, which would include the maximum amount of time that eggs would normally be held on the farm), the eggs should be held at a temperature of approximately 45° F.

Humidity

Table 3 gives the changes in these same measures of interior quality that occur under varying conditions of humidity, at a temperature of 55° F. The least change in all measures except loss in weight occurred at a relative humidity of 40 percent. The greatest decline in albumen quality occurred with a relative humidity of 85 percent. Loss in weight was least at a relative humidity of 85 percent. This is in agreement with other experimental data and observations. These data indicate that a high humidity was most desirable from the standpoint of loss in weight of eggs, but that at low humidity there was less change from the new-laid condition in albumen quality. Therefore, the optimum moisture content of the air would appear to approximate 60 percent relative humidity.

It should be noted here that under present-day marketing conditions, where eggs produced close to consumption centers move rapidly to the actual consumer, the loss due to evaporation may overcome the saving in actual firm white quality at the lower relative humidities. Thus it may readily be more economical to maintain the full contents of the egg in this short-time marketing procedure than to maintain the condition of the firm albumen, particularly since the slight differences shown here are not easily seen in the customary candling procedure of today.

TABLE 2.—*The changes in various measurements of interior quality that occur with passing time at constant holding temperatures and relative humidity of 85 percent*

Temperature 55° F.

Measure	Fresh	Held 4 days Change	Fresh	Held 8 days Change	Fresh	Held 10 days Change
1. Condition of firm albumen	2.00	+0.30	2.02	+0.63*	1.84	+0.86*
2. Percentage of firm albumen	50.73	+2.39	51.63	+3.69*	50.55	+2.80
3. Percentage of inner thin albumen	22.85	−2.30	22.11	−8.22*	24.13	−6.81*
4. Percentage of outer thin albumen	26.42	−0.09	26.29	+4.50*	25.32	+4.00
5. Yolk index	.416	− .001	.416	− .003	.433	− .021*
6. Loss in weight in grams	....	.199	....	.240	....	.346

Temperature 80° F.

Measure	Fresh	Held 4 days Change	Fresh	Held 8 days Change	Fresh	Held 10 days Change
1. Condition of firm albumen	1.96	+ 1.05*	2.08	+ 1.60*	....	....
2. Percentage of firm albumen	52.10	+ 4.47*	52.13	+ 4.82	....	....
3. Percentage of inner thin albumen	21.62	−10.14*	20.62	−16.57*	....	....
4. Percentage of outer thin albumen	26.29	+ 5.66	27.25	+11.75*	....	....
5. Yolk index	.418	− .017*	.416	− .063*	....	....
6. Loss in weight in grams	....	.572	....	1.093	....	....

* Significant—odds against so great a difference being due to chance alone greater than 100:1.

TABLE 3.—*The changes in various measurements of interior quality that occur during a 10-day holding period under varying conditions of humidity with a temperature of 55° F.*

Measure	Fresh	Relative humidity 85 percent Change	Fresh	Relative humidity 60 percent Change	Fresh	Relative humidity 40 percent Change
1. Condition of firm albumen	1.84	+0.86*	1.92	+0.72*	2.03	+0.35
2. Percentage of firm albumen	50.55	+2.80	50.88	+4.00*	52.18	+3.32
3. Percentage of inner thin albumen	24.13	−6.81*	22.88	−5.18*	23.14	−4.50
4. Percentage of outer thin albumen	25.32	+4.00	26.25	+1.18	24.68	+1.18
5. Yolk index	.433	− .021*	.424	− .005	.417	+ .014
6. Loss in weight in grams	....	.346	....	.568	....	.549
Date of test	January 1935		April 1935		September 1935	

* Significant—odds against so great a difference being due to chance alone greater than 100:1.

Handling

The effects of shaking eggs held under different conditions of temperature and relative humidity, for four days, are shown in table 4. In this experiment eggs laid by a group of pullets at the beginning of their production year were used.

No effort was made to obtain eggs from the same individuals for each of the tests, as in the preceding experiments, since it has been shown that the eggs of pullets at the start of their production cycle are very uniform. Those eggs that were shaken were placed in the center of a 15-dozen case, with added weights to make the total weight equivalent to a standard full one-half case. The eggs were stored under conditions indicated in each instance and then shaken to simulate the handling they would receive if farm held and then shipped to market. Examination of the egg quality was made immediately following the shaking. Control runs were made of new-laid eggs, not shaken, and shaken for 10 minutes.

Two test runs were made for each condition of temperature and humidity and since the data of neither differed significantly from the mean of both they were combined in the summary of results.

In table 4 are listed for comparison the observations on the new-laid unshaken eggs and the net change in each of the measures of quality for eggs subjected to the various conditions indicated. Those changes from the new-laid, unshaken condition which are statistically significant are indicated by an asterisk (*). In all cases where eggs were shaken, whether new-laid or after holding, a decline in quality was observed. However, those eggs held under higher temperature and lower humidity showed the greatest decline. Those eggs held four days at 55° F. and 85 percent relative humidity showed less unfavorable change when shaken for either 10 or 20 minutes than the eggs held under room conditions (73° F., 55 percent to 70 percent relative humidity), again indicating the importance of temperature.

TABLE 4.—*Effect of shaking after holding on interior quality of fresh and held eggs*

Measure	Fresh, not shaken	Shaken 10 minutes			Shaken 20 minutes	
		Fresh	Held 4 days at 55° F. and 85 percent relative humidity	Held 4 days at 73° F. and 55-70 percent relative humidity	Held 4 days at 55° F. and 85 percent relative humidity	Held 4 days at 73° F. and 55-70 percent relative humidity
		Change	*Change*	*Change*	*Change*	*Change*
1. Condition of firm albumen	1.28	+0.39*	+0.99*	+1.21*	+1.07*	+1.33*
2. Percentage of firm albumen	51.25	−1.30	−0.79	+3.10*	−0.55	+1.45
3. Percentage of inner thin albumen	26.81	+0.24	−0.37	−4.45*	−1.46	−4.72*
4. Percentage of outer thin albumen	21.94	+1.06	+1.16	+1.35	+2.01	+3.27
5. Yolk index	.469	+ .004	−0.004	−0.024*	−0.006	−0.043*
6. Loss in weight in grams			0.26	0.45	0.24	0.56
Number of eggs	69	64	61	63	61	64

* Significant—odds against so great a change being due to chance alone greater than 100:1.

These data indicate that rough handling is an important factor in lowering egg quality and that it should be avoided in so far as possible.

SUMMARY AND CONCLUSIONS

In order to determine the physical changes that occur in eggs and the optimum conditions of temperature and humidity for the short-time farm holding of eggs, tests were made at temperatures between 35° F. and 80° F. and under relative humidity conditions of 40 percent to 85 percent. A mechanical shaker was used to determine the effect on eggs of rough handling which might occur on the farm or during shipment. It may be concluded from the examination of more than 4,800 eggs from specially tested birds that:

1. Candling tests are not satisfactory for the accurate determination of the small differences in interior egg quality found in the short-time holding of eggs.
2. A short-time farm holding temperature for eggs should approximate 45° F.
3. The selection of an optimum moisture level must be a compromise between the effects upon shrinkage and upon the breakdown of the firm albumen. These tests indicated that a relative humidity of approximately 60 percent produced satisfactory results.
4. Eggs should be handled with a minimum of mechanical jarring or disturbance.

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FACTORS AFFECTING INTERIOR EGG QUALITY

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Egg quality has been defined in many different ways by workers employing various methods of measurement. We can probably give no better definition than the very general one given by Jull (*5*): "The term 'quality' when applied to market eggs means that condition of the shell and contents of eggs which can be marketed in such a manner as to give the greatest satisfaction to the consumer." Many different factors are recognized as interior egg quality factors; air cell size, yolk color, condition of the yolk, and condition of the albumen are some of the more common. It is difficult to say which is the most important of these factors, but for the purpose of this paper the discussion will be limited to factors affecting albumen quality, specifically as measured by the albumen index.

REVIEW OF PREVIOUS INVESTIGATIONS

Methods of measuring albumen quality have been reviewed by Parsons and Mink (*9*), Heiman and Wilhelm (*3*), Wilcke (*13*), and Wilhelm and Heiman (*15*). The effect of temperature during the storage period on albumen quality has been discussed by Wilhelm and Heiman (*16*). Seasonal variations in albumen quality have been reported by Hunter, Van Wagenen and Hall (*4*) and by Wilhelm and Heiman (*15*). Titus (*12*), Sowell and Morgan (*11*), and Miller and Bearse (*7*) all report that various protein supplements when fed to laying hens did not affect albumen quality. Card and Sloan (*2*) report that sodium silicate, ground limestone, salt, magnesium oxide (MgO), and potassium carbonate (K_2CO_3) did not affect albumen quality. However, North (*8*) has presented evidence that the feeding of rye resulted in poorer albumen quality. Miller and Bearse (*7*) have presented evidence that the higher producing birds tend to lay eggs of poorer albumen quality, but the reports of Knox and Godfrey (*6*) and of Wilhelm and Heiman (*15*) do not substantiate this evidence. Almquist, Nelson, and Lorenz (*1*) report that while shaking may cause a tremulosity of air cell, it apparently does not cause a liquefaction of the firm albumen. Sharp (*10*) gave an excellent review of literature on the preservation and storage of hens' eggs.

PROCEDURE

The process of measuring the percentage albumen index loss due to treatment is quite simple. Hens are classified according to their albumen index, Wilhelm and Heiman (*14*) by breaking from each bird at least four consecutive eggs which have been held overnight at 50°-60° F. with a relative humidity of 75-85 percent and measuring the albumen index of each egg. If the index readings do not vary from the average of the indexes more than ±10, the hen is said to be constant for this character. The succeeding eggs produced during the next 30 days by each hen are then assigned this index number. These eggs may be subjected to various treatments with reasonable assurance that they are the same as the average albumen index ±10. After experimental treatment the eggs are broken and the albumen index is taken. The difference between the classified or initial albumen index, and the experimental or final albumen index is the albumen index due to treatment. The percentage albumen index loss is calculated by the formula

$$\text{Initial index} - \text{final index} = \text{difference.}$$

$$\frac{\text{Difference}}{\text{Initial index}} \times 100 = \text{percentage albumen index loss due to treatment.}$$

RESULTS AND DISCUSSION

The effect of time

The albumen index taken while the egg is still warm is about 18 percent greater than when it is taken on the following day. The procedure of classifying hens according to their average albumen index as outlined by Wilhelm and Heiman (*14*) recognizes this fact. This rapid initial loss in interior quality has not been widely recognized. Such losses may be attributed to gaseous exchange, to enzymatic action, or to the effect of temperature. Warm eggs subjected to temperatures of 40° and 90° F. lost essentially the same amount of interior quality in ten hours, when the humidities were the same. Obviously temperature had no effect on this rapid change in interior quality. Such losses may be attributed to the "time factors," gaseous losses, or enzymatic action.

Further effects of time on interior quality of eggs may be seen from figure 1. It will be observed that when eggs which were 24 hours old are stored at 30° F. with a humidity of 75–78 percent, a further loss of 22 percent occurred in 20 days after which the loss was quite gradual. This loss was still continuing, however, at the end of 192 days of storage.

The effect of temperature

Figure 1 shows the differences in percentage of albumen index of eggs stored at 30°, 50°, 70°, and 90° F. for periods ranging in time from 3 hours to 192 days. By reading on the horizontal line a direct comparison of the effects of temperature on albumen quality may be made. For example, a 40-percent loss in albumen index was obtained at 90° in 20 hours, at 70° in 3 days, at 50° in 24 days, and in 134 days at 30° F. This emphasizes the need of low temperatures in the storage or holding of eggs and also the need of frequent

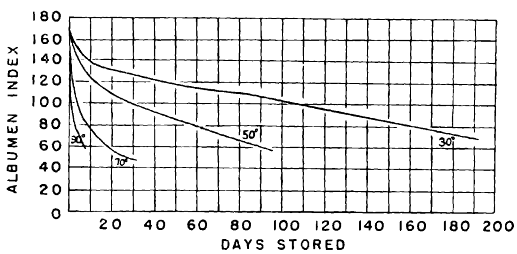

FIGURE 1.—The effect of temperature on albumen quality as measured by the albumen index loss of eggs held at 75–78 percent humidity.

gathering of eggs in warm weather. It also brings out the fact that there is a definite need for refrigeration or cooling facilities everywhere eggs are handled whether it be on the farm, in the trucks hauling the eggs to market, in the candling room, in the storage warehouse, in the store retailing them, or in the home of the consumer.

The effect of humidity

Few experimental data are available on the effect of humidity on albumen quality losses. Many general recommendations on the care of eggs held or stored have been made. Most of these recommendations are based on the assumption that the highest humidity obtainable without causing molds is the best humidity for holding eggs. It is a general observation that under normal conditions as the size of the air cell increases, the interior quality of the egg decreases. Oil treatment of the egg shell, or holding eggs at a high humidity will tend to prevent any great increase in air cell size.

Investigations at the Washington Agricultural Experiment Station have shown that high humidities will not prevent some albumen quality loss. When eggs were gathered hourly and held in clean, cool water at a temperature of 51° F. for four days no air cell developed but a loss in albumen index of 13.8 percent occurred. Control lots of eggs held at the same temperatures but with an 82-percent humidity lost 17.8 percent of their albumen quality.

An experiment was designed to observe the effect of various humidities on the albumen index losses of eggs. Twenty hens were classified as to their individual albumen index. Succeeding eggs were held four days at relative humidities of 90, 70, and 50 percent with a room temperature of 60° F. The average percentage losses in albumen index were 14.7, 20.0, and 23.1, respectively.

The effect of season

Figure 2 shows a steady decline in albumen quality as measured by the albumen index for the first nine periods or until about July 1 re-

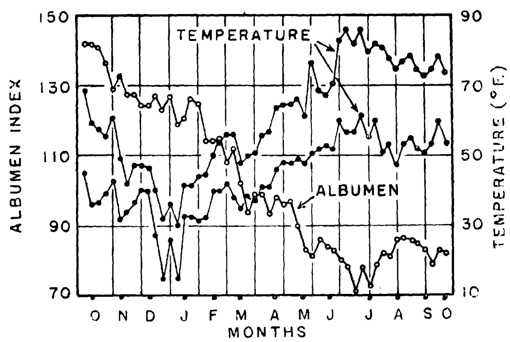

FIGURE 2.—Average weekly albumen index and maximum-minimum temperature (house) by 4-week periods from October 17, 1936 to October 15, 1937.

gardless of a 60-degree variation in temperature. It might be well to point out, however, that for these nine periods the maximum temperature in the pens was below 70° F. During July when the highest maximum temperature (86° F.) was reached, the lowest average albumen index was observed. However, the succeeding 4-week drop in temperature of 15° F. occurred at the same period when the albumen index stopped declining. These data indicate that there is a consistent albumen index loss until July which is not affected by weather conditions. These observations are in substantial agreement with those of Hunter, Van Wagenen and Hall (*4*). It must be remembered that under normal conditions where the eggs are not gathered frequently, high temperatures after the egg is laid would affect the albumen index, but that under the conditions of this experiment there seemed to be little relationship between albumen index and temperature though a definite seasonal change did occur.

The effect of ration

Titus (*12*) aptly summarizes the effects of the nutrition of the laying hen on the composition of her egg when he states that feeding for albumen quality seems remote or unlikely.

Unreported data from the Washington Agricultural Experiment Station indicate a tendency for birds fed low-protein rations to produce eggs of slightly better albumen quality than those receiving high-protein rations. Investigations with small numbers of hens in laying batteries indicated that all of the cereal and protein supplements commonly found in the Washington Laying Mash No. 1 when added in large amounts to an adequate basal ration did not improve albumen quality. The low exception was alfalfa leaf meal. Alfalfa leaf meal, succulent alfalfa, alfalfa range, kale, and lawn clippings, when used to supplement the dry basal rations produced eggs of better albumen quality. Other ingredients tested were domestic yellow corn, Argentine yellow corn, barley, wheat, oats, rye, soybean meal, cottonseed meal and green pea meal, and Alaska herring and salmon fish meals.

Effect of production

Percentage production and average albumen index were correlated as follows:

During the first 10 weeks........ $r = -0.0123 \pm 0.0909$
During the first 20 weeks........ $r = +0.2191 \pm 0.0981$
During the first 40 weeks........ $r = +0.3699 \pm 0.1045$
For the year, 52 weeks........... $r = +0.3068 \pm 0.1274$

Miller and Bearse (*7*) report significant negative correlations between total egg production and the average albumen index for all periods, indicating that the higher producing birds tend to lay poorer quality eggs. Knox and Godfrey (*6*) report negative correlations between both total egg production and weight of the thick albumen in relation to total egg weight, and between percent production and weight of the thick albumen in relation to the total egg weight. Their correlations were too small to be considered significant, however. From the data presented here, it would appear that there is no tendency for birds of high production to produce eggs of poor albumen quality.

The effect of shaking

The mechanical jars, vibrations, and shaking to which eggs are exposed during transportation to market are probable causes of changes in the interior quality of those eggs. Almquist, Nelson, and Lorenz (*1*) have shown that mechanical jars cause broken-down and loose air cells in eggs, but does not cause a liquefaction of the firm white. Refrigerator cars of eggs shipped from the Pacific Coast to New York City require from 8 to 12 days for the journey. Apparatus was designed to imitate the jarring, side-swaying motion of a refrigerator car in transit. An experiment was designed to see if the breaking down of the air cell was accompanied by a break-down in albumen quality as measured by the albumen index.

By checking the condition of the air cell every 6 hours when the shaker was operated at a room temperature of 50° F. and a relative humidity of 85 percent, it was found that 50 percent of the air cells were classified as slightly tremulous, or worse, in 24 hours.

TABLE 1.—*Percentage albumen index loss due to shaking*

Lot no.	Age of eggs	Experimental conditions Temperature 50° F., humidity 85 percent	Albumen index loss
	Days		*Percent*
1	1	Shaken 24 hours continuously	19.5
2	1	Control—no shaking	18.7
3	4	Shaken 24 hours continuously	25.3
4	4	Control—no shaking	28.3
5	14	Shaken 24 hours continuously	43.0
6	14	Control—no shaking	40.0
7	12	Shaken 2 hours daily for 12 days	40.0
8	12	Control—no shaking	37.5

TABLE 2.—*Percentage albumen index loss of eggs treated to prevent loss of carbon dioxide*

Time stored	Egg carton control	Air tight container	Carbon dioxide	14-inch vacuum	Vacuum CO_2 release
Eggs stored at 90° F.					
Days	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	45.7	29.1	10.1	18.2	6.5
2	56.2	36.3	20.3	31.3	14.8
4	65.1	37.1	22.5	38.4	13.4
8	71.7	47.2	35.3	48.6	35.3
Eggs stored at 70° F.					
7	54.6	34.3	21.6	35.0	7.4
14	63.5	34.7	21.4	36.7	19.4
28	68.3	50.0	17.9	56.4	26.1
56	79.2	56.0	33.0	52.0	26.0
Eggs stored at 50° F.					
3	21.4	1.8	+5.9	3.1	1.9
6	18.7	10.3	+0.9	4.9	+4.5
10	26.5	4.7	+5.5	9.4	+2.0
18	36.2	10.1	7.4	14.6	0.9
Eggs stored at 30° F.					
6	2.2	+1.7	+4.7	+3.9	+0.7
24	7.9	3.6	5.0	4.9	5.6
45	20.7	18.1	16.2	18.2	16.0

No consistent differences between the control lots and eggs shaken for 24 hours appeared (table 1). The percentage loss in albumen index of all lots subjected to the shaking treatment is not significantly different from those of eggs held under the same conditions of temperature and humidity. While shaking does affect air cell tremulosity, it apparently has little effect on the condition of the albumen.

The effect of carbon dioxide

Many investigators have pointed out that as the interior quality of the egg decreases the pH of the egg increases. This is due to the gaseous exchange between the egg and the surrounding air. Both nitrogen and carbon dioxide have been used in egg storage warehouses to help prevent quality losses and mold growths. We now know that under average conditions by the time the egg reaches the storage warehouse much of its initial quality has been lost. Sealing fresh eggs in airtight containers, vacuum packing, or adding carbon dioxide to an airtight container should all be effective means of reducing the carbon dioxide loss from eggs. An experiment was designed to test the effects of these different methods of treatment at temperatures of 90°, 70°, 50°, and 30° F. The results of this experiment are summarized in table 2.

None of the treatments were superior to eggs packed in cartons when the eggs were stored for periods up to 45 days at 30° F. The packing of eggs in airtight containers effectively reduced albumen quality losses below those of the control lot when held at temperatures above 30° F. However, at the higher temperatures there was a tendency for molds to develop. The use of carbon dioxide in containers of fresh eggs resulted in a turbid or smoky albumen, but was effective in preventing albumen index losses even at high temperatures. Vacuum packing of fresh eggs was superior to ordinary carton packing (control lots), but had little advantage over the airtight container for retarding quality losses. Vacuum packing usually resulted in an adhering of the thick albumen to the shell membranes. Eggs stored in a vacuum released with carbon dioxide were superior to the control lots at temperatures above 30° F. but they were not consistently superior to the eggs packed in carbon dioxide.

SUMMARY

The procedure of classifying hens according to their albumen index and computing the percentage albumen index loss due to treatment is described.

Eggs lose albumen quality rapidly after they are laid. Evidence is presented that the time factor may be responsible for quality losses despite temperature or humidity. Temperatures of 30° F. retard albumen index loss markedly after a 30 percent loss has occurred. Temperatures of 50°, 70°, and 90° F. are less desirable for storage of eggs than 30° F. Humidity will not prevent all albumen quality losses, but the amount of loss is proportional to the humidity. There is a definite seasonal trend in quality losses of fresh laid eggs which does not appear to be directly influenced by temperature. Rate of production or total production does not affect albumen quality. Time, temperature, and humidity must be responsible for albumen quality losses during shipment, as shaking did not result in a breakdown of the albumen structure. Packing of eggs in airtight containers or in an atmosphere of carbon dioxide is superior to vacuum packing or to the usual method of packing in retarding albumen losses. Keeping eggs in carbon dioxide effectively reduces albumen quality losses at temperatures above 30° F.

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UNIT FOR MEASURING EGG STORAGE CONDITIONS

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The judgment of interior egg quality by the consumer and by the scientist, with the exception of color of yolk and flavor, is based fundamentally on the appearance of the broken-out egg, which includes the stand-up ability of the yolk (measured by the yolk index), the amount of thick white (measured by the percentage of the thick white of the total), the stand-up ability of the apparent thick white (measured by the observed condition score), albumen index, the height of the thick white, and Haugh units (*H.U.*).

Since the judgments of interior egg quality are based by both the consumer and the scientist on the difference in appearance of the broken-out eggs, it will be of interest to compare the correlation coefficients between these different interior egg quality measuring scores. Several such values taken from recent scientific publications are shown in table 1. It seems safe to assume that when no correlation coefficient figure has been published the correlation is very small or zero.

Table 1.—*Coefficients of correlation between scores of selected interior egg quality factors, in fresh eggs*

Item	Height of firm albumen	Albumen index	Percentage of thick white	Yolk index
Observed condition score	−0.934 ±.006	+0.846 ±.022	−0.242 ±.063	−0.006 ±.067
Height of firm albumen	....	+.986 ±.001	....	....
Albumen index	....	....	....	....
Percentage of thick white	....	....	....	+.021 ±.067

Table 1 shows the correlation coefficients between various interior egg quality measurements taken from fresh eggs and eggs taken at random (*1*, *2*, and *3*). Correlation is good between the observed condition score, and both the height of the firm albumen and the albumen index and between the latter two, but there is little correlation between any of the other egg quality measurements.

The correlation between the height of the firm albumen and the albumen index is practically perfect if the weight of the eggs is held constant, shown by the coefficient of +0.986 ±.001. Therefore the measurement of the height of firm albumen may be used instead of the more complicated albumen index method of measuring interior egg quality.

While the correlation between the albumen height and the albumen index is practically perfect, the numerical values of these measurements do not represent true egg quality. For example, a reduction in the albumen height from 10 mm to 5 mm or in the albumen index from 140 to 70, which is a 50-percent reduction in these measurements may be observed in eggs the quality of which has changed hardly one commercial grade. To overcome such discrepancies between the numerical value of the egg-quality measuring unit and its quality value, a mathematical quality-measuring unit was developed (*4*) called the Haugh unit, based on the fact that the apparent egg quality varies logarithmically with respect to albumen height. This Haugh measuring unit is given by the following mathematical formula

$$100 \log H \qquad \text{I}$$

This formula indicates the number of quality measuring units that are in the egg. If the height of the albumen is 10 mm there are 100 Haugh units in the egg. If the height of albumen drops to 1 mm the quality is zero.

Quality loss in Haugh units or the difference in quality between eggs is measured by the formula

$$100 \log \frac{H}{H_1} \qquad \text{II}$$

H is the firm albumen height in mm on the date of storage

H_1 is the firm albumen height in mm after being in storage

The height measurements in these formulas are based on a 2-ounce egg. For changing the height of albumen of eggs of other weights to the equivalent 2-ounce egg the following formula can be used (*4*, *5*).

$$H_2 = H_W - \frac{\sqrt{G}(30.0\ W^{.37} - 100)}{100} + 1.9 \qquad \text{III}$$

In which H_2 is the equivalent height of albumen of a 2-ounce egg.

HW is the height in mm of an egg of weight W

G is 32.2

W is the weight of the shell egg in grams

This formula is correct for eggs weighing between the limits of 40 grams and 70 grams.

The correlation of +0.846 ±.022 between the observed condition score and the albumen index is fair. The correlation of −0.934 ±.006 between the observed score and the albumen height is very good and is shown in the correlation table 1 by Wilgus and Van Wagenen (*3*). While the correlation is good the distribution of data in that table shows that for different values of the observed condition score and of the albumen height does not vary as a linear function, which also indicates that egg quality as represented by albumen height does not represent true egg quality, but when the albumen height is plotted against the observed condition score and Haugh Units (*4*) the latter two quality units coincide. This proves that egg quality varies as the logarithm of the albumen height and can be represented by formula I.

A comparison of tables 1 and 2 reveals that the gross correlations between different egg quality measurements are better when there has been some deterioration. The reason for this is that physical measurements of egg quality do closely reflect deterioration in egg quality. Changes that take place in the height of the thick white, for example, as egg quality becomes progressively impaired, can be observed by the consumer and can be measured by the scientist. Various observers have pointed out that measurements of deterioration of eggs due to time and temperature are not linear, and all the data so far examined by the author have shown that egg quality measurements plotted against time result in a curve. (*1*, *2*, *3*, *4*, *5*, *6*, *7*, and *8*).

During the storage of eggs, certain definite physical changes take place in the white of the eggs very rapidly when the eggs are first placed in storage and very slowly after the eggs have been in storage for a long period. (*1*, *2*, *4*, *6*, and *7*). In other words, these changes and the curves representing them are not linear. But as most natural phenomena follow some definite law, it is often possible to find mathematical expressions for these laws. It was pointed out in 1934 by the author (*9*) that the deterioration in egg quality may be expressed by a negative logarithm.

TABLE 2.—*Coefficients of correlation between scores of selected interior quality factors in eggs after time and temperature changes have taken place*

Item	Height of firm albumen	Albumen index	Percentage of thick white	Yolk index
Observed condition score	......	+0.947 ±.007	+0.707 ±.034	+0.697 ±.035
Height of firm albumen	......	+.986 ±.001	......	......
Albumen index	......	......	......	......
Percentage of thick white	......	......	......	+.613 ±.042

From analysis of recent experimental data the author has found that the rate of change of egg white quality due to storage conditions may be stated by the following general exponential formula

$$H_1 = H\,(d)^{-u} \qquad \text{IV}$$

in which H_1 is the firm albumen height in mm after d days in storage

H is the firm albumen height in mm on the date of storage

d is the number of days in storage

u is the depreciation constant for a given set of storage conditions.

Taking the log of both sides of the equation IV

$$\text{Log } H_1 = \log H - u \log d$$
$$u \log d = \log H - \log H_1$$

$$u = \frac{\log \dfrac{H}{H_1}}{\log d} = \frac{\text{Haugh units}}{\log d} \qquad \text{V}$$

Formula V states that the rate of change of egg quality (u) varies as the ratio of the logarithms of the two different height measurements divided by the logarithm of the number of days in storage; in other words, the depreciation constant (u) equals Haugh loss units (formula II) divided by the logarithm of the number of days in storage.

The egg depreciation law (u) as stated in equation V is shown graphically by the smooth curve in figure 1. To show that this is the equation of a straight line it may be tested by the plotting of log H_1 against log d. The ordinates are values

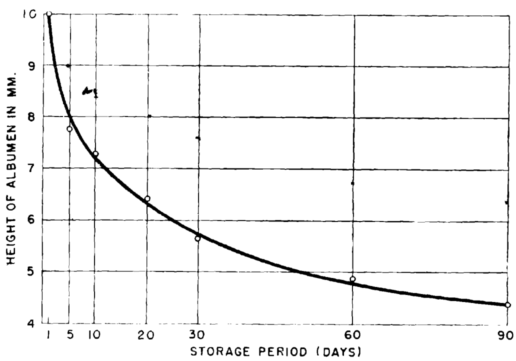

FIGURE 1. Effect of storage (50° F) for varying periods of time on the albumen height. The storage depreciation constant u of the curve is 1.169.

of log H_1 the abscissas are values of log d. Log H is the intercept on the ordinate and the depreciation coefficient (u) is the slope of the straight line, the negative sign indicating that the slope is downward from left to right.

Different cold storage houses and different methods of storing shell eggs will have different slopes or values of (u). The smallest slope will indicate the least deterioration and the greatest slope will indicate the greatest deterioration. The numerical value of (u) represents the rate of depreciation of egg quality and is constant for any given set of conditions.

For practical use, several constants will have to be added to the general formula IV so that the exponent (u) will be a whole number instead of a fractional number. The formula then becomes:

$$H_1 + 100 = (H + 100)d^{-\frac{u}{100}} \qquad \text{VI}$$

or

Depreciation constant u =

$$u = \frac{100\,[\log\,(H - 100) - \log\,(H_1 - 100)]}{\log d} \qquad \text{VII}$$

The results in figure 1 were obtained by using the eggs of 25 White Leghorn pullets having an average albumen height of 10 mm 24 hours after they were laid and weighing approximately 2 ounces each. Each day's production was put in storage at a temperature of 50 degrees and approximately 65-percent humidity. At the end of each storage period (5, 10, 20, 30, 60, and 90 days) a day's production was taken out of storage and the eggs were broken out to measure the average albumen height (table 3). The smooth curve in figure 1 was computed using the first and the last observations in table 3.

TABLE 3.—*Height of albumen as computed by use of Formula VII compared with measured height*

Storage period	Measured height	Computed height	Deviation
Days	*Mm*	*Mm*	*Percent*
1	10.00	....	....
5	7.75	7.95	−2.52
10	7.21	7.08	+1.83
20	6.40	6.31	+1.43
30	5.65	5.71	−1.05
60	4.82	4.76	+1.26
90	4.38	....	....

Depreciation constant u =

$$\frac{100\,[\log\,(10 - 100) - \log\,(4.38 - 100)]}{\log 90} = 1.169$$

Looking at these plotted points or the curve in figure 1, it will be noted that as the days in storage increase the height of the albumen decreases. This descending concave curve with a negative slope is a hyperbola with the axis as asymptotes.

The formula summarizes the data with reasonable accuracy over the range of 1 to 90 days. It appears likely that the formula will be good for periods above 90 days, but additional experiments will have to be made to verify this point. Some tests that are now being made indicate that formula VI will work for fractions of a day if the right technique is used, such as cooling the eggs to storage room temperature immediately after being laid. The results in table 3 show that the value of the depreciation constant (u) is independent of the time in storage. Knowing the depreciation constant (u) for different methods of storing shell eggs, it will be possible to compare these different methods, and prove which method is the best.

The results published by Wilhelm and Heiman (*6*) showing the average percentage loss in albumen index for eggs stored for various periods and temperatures follow the same general formula. Two other methods of measuring egg quality which offer great possibilities have been developed recently. They are not given in tables 1 or 2 because no correlation coefficients have been published. The first method was evolved by Parsons and Mink (*10*) and is known as the albumen area index, which is the ratio of the area of the thick white to its weight. The second method was developed by Hoover (*8*) who has an ingenious way of measuring the area of the thick white. He shows by means of semilogarithmic paper that the relationship between area of thick white in sq. cm and egg quality units is logarithmic. This relationship can be expressed by the following formula

$$H.U. = 100\,\frac{2 - \log\,(\text{area in sq. cm})}{0.35} \qquad \text{VIII}$$

Standardization of methods and units is the most logical approach to the needs and problems affecting the egg industry. More accurate standards and units of measurements will allow closer supervision of the product and the conditions that affect the quality of the product. Closer supervision means better and more efficient methods of operation. This in turn means a better quality product with greater consumer acceptance and greater demand. Epitomized, the needs are:

(1) International standard conditions for testing interior egg quality.
(2) International standard units for measuring interior egg quality.
(3) International standard methods for determining rate of change of interior egg quality.
(4) International standard unit for measuring storage conditions.
(5) International standard sampling method for determining shell egg quality.

SUMMARY

During storage of shell eggs, certain definite changes take place in the white of eggs. Under some conditions these changes are slow and under some conditions these changes are rapid. Different measurements of the quality of the white have been demonstrated to correlate closely; for example, albumen index, height of the firm white, observed condition score, and the Haugh quality unit.

Methods of measuring white quality do not correlate with all factors of market values such as size, shape or cleanliness of eggs, color of egg yolks, etc. Nor do they correlate sufficiently for scientific measurement with yolk index, or the percentage of thick and thin white, although the latter measurements do usually accompany changes in the white in a reasonably close procession.

Most natural phenomena follow some definite law and it is often possible to express these laws

by mathematical formulas. The change in white quality has been shown to vary logarithmically.

From analysis of experimental results the author finds that the rate of change of egg white quality during storage varies according to the general exponential formula

$$H_2 = H_1 \, (d)^{-u}$$

in which H_2 is the firm albumen height in mm after d days in storage
H_1 is the firm albumen height in mm on the date of storage
d is the number of days in storage
u is the rate of change of quality of the white for a given set of storage conditions.

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CHANGES IN OVOMUCIN DURING EGG STORAGE[1]

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Most of the recent workers in the field of egg quality have assumed that ovomucin is the protein of egg white which is responsible for the gelatinous properties of the white. It is the only one of the proteins isolated from egg white (*4, 8*) which could, of itself, be responsible for a gel structure under the condition present in the egg. McNally (*6*) has shown that nearly all of the mucin is to be found in the "thick" or gelatinous part of the white. Since the observed quality of the white depends on the gelatinous properties of the white, the changes in observed quality of the white during storage must be associated with some change in the colloidal properties of the ovomucin.

Balls and Swenson (*1*) after studying a "trypsin-like enzyme" found in egg white postulated that the disintegration of the mucin gel during egg storage was the result of hydrolysis of the mucin by this enzyme. Manen and Rimington (*5*) have investigated the same enzyme and describe it as "erepsin-like." They state that it does not hydrolyse the proteins of egg white, and suggest that the disintegration of the mucin gel may be produced by a "disaggregating enzyme" which would break up the mucin structure without hydrolysing the peptid chains of the molecule.

Sharp (*7*) has found that the hydrogen ion concentration of the white has a very decided influence on the gel properties of the ovomucin in egg white, as well as on the preservation of the yolk during storage. A large part of the inorganic matter of the white is sodium and potassium bicarbonate, and in ordinary storage, this solution loses carbon dioxide through the shell and becomes alkaline. Sharp shows that the high pH which ordinarily results from this process causes the white to become much less gelatinous. He further shows that this change can be greatly retarded by preventing the loss of carbon dioxide from the egg.

The work of Manen and Rimington, and that of Sharp, casts considerable doubt on the hypothesis that the enzymatic hydrolysis of the mucin is an important cause of watery whites in stored eggs. There remains to be studied the effect of the disaggregating enzyme suggested by Manen and Rimington and the mode of action of high pH on the mucin gel. The present study is an investigation of these factors.

[1] Contribution No. 244, Department of Chemistry, and No. 121, Department of Poultry Husbandry.

EXPERIMENT

The 13 pullets laying the eggs used in the present study were confined to a laying battery and had access to water and an all-mash diet at all times. The eggs, all of which were infertile, were produced from three to six months after the individual birds had reached sexual maturity. To hasten deterioration, the eggs were stored at a temperature of 35° Centigrade, and it was assumed that essentially the same changes as occur during low temperature storage would occur at this higher temperature, but at a much more rapid rate. The primary purpose was to study changes due to enzymes, and these would certainly be favored by the higher temperature.

Eggs from these pullets were studied: (1) When fresh (2) after holding for 8 days at 35° Centigrade, and (3) after holding for 6 weeks at 35° Centigrade, after the shells had been sealed with shellac and paraffin the day following laying.

For the analytical studies, the eggs were broken and the quality of the white measured by the method suggested by Haugh (*3*). The pH of the white was determined by means of a glass electrode. Mucin, computed as the percentage of the total nitrogen present, was determined by the following procedure. The entire white was diluted to 200 cc with water and the gelatinous material broken up by means of a mechanical stirrer. Following this, acetic acid was added to make a concentration of 1 percent, and the precipitated mucin centrifuged out. The mucin was washed seven times with 80 cc of 1-percent acetic acid, stirring and centrifuging each time. The sixth wash solution was allowed to stand overnight in contact with the precipitate before centrifuging. After the seventh washing the mother liquor and washings were combined and the amount of nitrogen present in this solution, and in the washed mucin was determined. It was found that under these conditions of washing, the seventh wash solution contained only about 2 percent as much nitrogen as the mucin precipitate. The acetic acid added at first would not have been necessary in the case of fresh eggs, but was found to be desirable in the case of the eggs which had been stored.

TABLE 1.—*Effect of high temperature on egg white*

Condition	Quality	pH	Mucin
	Haugh units		*Percent*
Fresh eggs	86.9	8.22	2.11
Stored 8 days at 35° C.	50.1	9.45	1.83
Sealed at 35° C. and stored 6 weeks	53.4	7.35	2.08

At least one, and usually several, eggs laid by each hen were analyzed fresh and others after storage under the two conditions described. The average results for the group are given in table 1. While some hens consistently laid eggs containing more or less mucin than the average, considerable variation in the mucin content even of fresh eggs laid by a given hen was observed.

The structure of the mucin gel of eggs laid by the same hens was examined histologically. The eggs were boiled for five minutes and a section of white removed from the midregion. Following fixation in Susa's fixative, the coagulated white was washed in water, dehydrated and cleared in dioxane, embedded, sectioned at 8–10 microns, and stained with thionine blue. No difference was found between fresh eggs and eggs laid by the same hens, which had been held for 8 days at 35° Centigrade. That the mucin fibers maintain their integrity during storage for 8 days at 35° C. is illustrated in figure 1. The comparison shown in the photomicrographs of the fresh and the stored eggs laid by hen 54 is typical of all individuals studied.

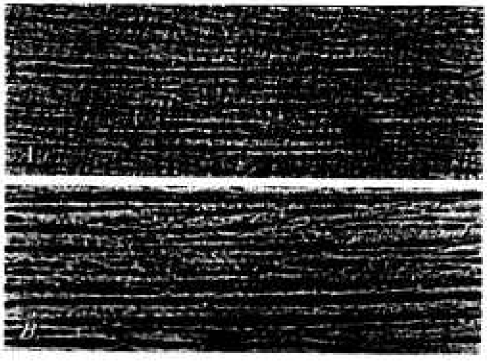

FIGURE 1.—Photomicrographs of mucin fibers in firm white. *A*, fresh egg, and *B*, egg held eight days at 35° C. × 400.

DISCUSSION

A striking fact to be observed from the table is the low pH of the eggs which had been sealed and stored. Since these were held a day before sealing, the pH of the white must have been about 8.5 at the time they were sealed and placed in storage. The fact that the white has a pH of 7.35 after storing 6 weeks indicates either that some acidic compound has been formed in the white from the break-down of its proteins, or that some acidic compound has diffused from the yolk out into the white. From the pH measurements of yolk and white made by various workers and reported by Grossfeld (*2*), it appears that as the white becomes more alkaline, the yolk becomes more acid. Therefore, the yolk might easily be the source of the acid which appears in the white of the sealed eggs. So far as has been determined, the autolytic changes occurring in the yolk are much more pronounced than those found in the white. This is additional evidence which points to the yolk as the source of the acid formed.

The fact that the observed quality is practically the same in eggs stored 6 weeks after sealing as in those stored 8 days without sealing demonstrates conclusively the importance of loss of carbon dioxide as a factor controlling egg deterioration. However, the fact that the sealed and stored eggs show such low quality, although their pH is low, indicates that some factor besides pH plays an important role in storage deterioration.

It is believed that the mucin analyses disprove the contention that enzymatic hydrolysis or disaggregation of mucin is a factor in deterioration of storage eggs. If any such change did take place, it seems that it would most certainly cause a detectable decrease in the amount of mucin present when the eggs were stored for 6 weeks after the pH of the white had been allowed to rise to 8.5 before storage. No significant decrease in the amount of mucin was detected under these conditions. A slight decrease was found in those eggs which were stored without the shells having been sealed. In these eggs, the pH of the white rose to 9.45, and this high pH, acting at a temperature of 35° Centigrade for several days, might be expected to cause some changes in the proteins of the egg white. It has been observed by other workers that some proteins which can be isolated in pure form from fresh eggs cannot be isolated from stored eggs. This might very easily be due to the effect of the high pH alone, without any enzyme action.

The microscopic examination of the thick white failed to show any structural differences between fresh and stored eggs. Since the microscopic structure of the mucin gel does not change, it is suggested that the decrease in quality is associated with a change in the elasticity of the mucin fibers. This change might be due to a change in the structure of the molecules, but is more probably the result of a change only in the colloidal properties of the mucin. As has been pointed out by Sharp, the most important cause of this change in colloidal properties is the change in pH, although some other factors must play a rather important role.

SUMMARY

During egg storage, the gelatinous part of the egg white becomes more nearly fluid so that the white is described as "watery." This change is not due to an enzymatic hydrolysis of the mucin present, in fact if any decrease in the amount of mucin occurs, it must be due simply to the effect of high pH. The microscopic structure of the gel is not changed, therefore the change in properties must be due to a change in elasticity of the mucin fibers. The increase in pH plays a very important part in this change in elasticity of the fibers, but some other important factor must also influence it.

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THE APPLICATION OF INTERIOR EGG QUALITY MEASUREMENTS TO PRACTICAL PROBLEMS[1]

By Sam R. Hoover, *Ford Research Division, Bureau of Chemistry and Soils, United States Department of Agriculture, Washington, D. C., and* Cecil Rogers, *Division of Markets, Virginia Department of Agriculture, Richmond, Virginia, U. S. A.*

The final judgment as to the quality of an egg is based on its appearance, taste, and odor. The latter two fundamental factors are closely interrelated, and so far have not been successfully evaluated in a quantitative manner. In this particular matter the egg industry is in much the same unsatisfactory position as other basic food industries.

The appearance of the broken egg can be rather satisfactorily measured in a quantitative manner. The relative amount of the thick white has been measured in a variety of minor modifications based on the original work of Holst and Almquist (*3*). This method has been successfully applied to genetic investigations of the hereditary nature of interior egg quality (*5*), and to storage problems (*7*). It is not sufficiently delicate (*6*) to measure the differences found by the more recent photographic scoring technique of Van Wagenen and Wilgus (*8*); the height of the thick white worked out simultaneously by Heiman and Carver (*2*) and Wilgus and Van Wagenen (*9*); and the

[1] Food Research Division Contribution No. 420.

area of the thick white measured by Parsons and Mink (*6*) and later simplified in technique in the authors' laboratory (*4*).

All three of these measurements are based on the spreading away of the white from the yolk as the thick white weakens. The photographic score was set up arbitrarily, using a score from 1.0 to 5.0 by ½ units. Haugh showed (*1*) later that this score is an inverse logarithmic function of the height of the thick white. The photographic score is also a direct logarithmic function of the thick white area (*4*).

The basis for using the height or the area of the thick white as a criterion of interior quality (a measure of "appearance") is this correlation with the photographic score. The scoring technique is rapid and simple, but it is subjective and therefore must depend to some extent on the personality of the observer.

The measurement of the height of the thick white has been quite successful in the hands of persons experienced in its use. The height has been found to be a relatively constant value for each hen, with wide variations between hens of similar breeding kept under similar conditions. In a recent paper Wilhelm and Heiman (*10*) have furnished needed fundamental data on the rate of breakdown of the thick white, in which the striking effect of temperature on this process has been quantitatively measured.

The area of the thick white, of course, increases as the height decreases, and this observation has been used to develop the method used in this paper. A wooden plate was constructed with a very shallow concavity of $\frac{1}{32}$ inch. After several coats of black varnish, concentric circles of 2 cm to 7 cm radius were put on in white ink, and these were protected with a coat of clear lacquer.

The length and width of the ellipse of thick white are read by interpolation from the circles, and the area calculated from the equation of an ellipse. This area can be converted graphically to a percentage quality system based on the arbitrary scoring of the Cornell workers. Other experimental details and relationships are given in the publication referred to above (*4*).

The effect of handling and short-time holding on top quality fresh eggs is a practical problem that is assuming greater importance at present, for more eggs are well handled from the nest to the consumer than ever before, and there are great possibilities for future advancement along this line. The following experiment was performed to test the changes in candling grade and in interior quality that take place in absolutely fresh eggs held at 30° F. for a week.

EXPERIMENTAL TREATMENT OF FRESH EGGS

One case of White Leghorn eggs laid that day was obtained from a nearby producer at 11:00 a.m. At 12 o'clock, the eggs were put in a room at 30° F., numbered, and all candled at 2 o'clock the same day. The following treatment was given. All work was done at 30° F.

Lot I: 72 eggs. Candled, and broken.
Lot II: 144 eggs. Candled also on the 2nd, 4th, and 7th days, and broken on 7th day.
Lot III: 144 eggs. Candled also on the 7th day and broken on the 7th day.

The accuracy of the candling can best be judged by table 1, which is a copy of a typical page of the data obtained. The results are, of course, completely objective, for at least 144 eggs were candled each day by number. The candler also was handling large quantities of eggs in the or-

TABLE 1.—*Sample page of data*

Egg No.	Candling Grade				Length	Width	Thick White Area
	0 days	2 days	4 days	7 days			
					Mm	*Mm*	*Cm*²
21	x	x	x	st	84	68	45
22	s	s	x	x	90	64	45
23	s	x	x	x	90	62	44
24	x	x	x	st	90	64	45
25	x	x	x	st	96	76	57
26	s	s	s	x	100	60	47
27	s	s	x	x	84	60	40
28	s	s	x	x	80	60	38
29	x	x	x	st	90	72	51
30	s	s	x	x	98	62	48
31	x	x	x	st	....	....	....
32	x	x	x	x	90	60	42
33	s	s	x	x	94	60	44
34	s	s	x	st	80	60	38
35	x	st	st	st	84	52	34
36	x	x	t[1]	t	100	60	47
37	s	x	x	st	80	60	38
38	s	s	x	st	90	64	45
39	x	x	x	st	90	70	50
40	x	s	x	x	94	60	44

s = U. S. Special, except for size.
x = U. S. Extra, except for size.
st = U. S. Standard, except for size.
t = Trade, except for size.
[1] Egg No. 36 developed a sweeping white, first seen at 4 days.

dinary commercial practice at the same time. The length and width of the thick white areas are shown as well as the areas calculated from these figures. The relatively small spread of the area figures is evidence that area measurements obtained by using a small sample would give a satisfactory picture of the interior quality of eggs that had a common history. Grade specification for size of egg was waived.

The candling results are plotted in figure 1, using 3.0 for Specials, 2.0 for Extras, 1.0 for Standards, and 0 for Trades. Thus the initial figures of 2.55 indicate 55 percent Specials and 45 percent Extras. On successive candling there were, of course, Specials, Extras, Standards, and Trades in the same average, but so few of the eggs fell to Trades and so few remained Specials that the figure of 1.77 (Lot II at 4 days) indicates approximately 75 percent Extras and 25 percent Standards.

There was not sufficient change in the air cell size during the experimental period to affect the candling grade. The main loss in candling quality was due to increased visibility and mobility of the yolk, factors which are commonly believed to reflect the condition of the thick white. The extent of the drop in grade is surprising, the eggs that were candled four times reaching a candling

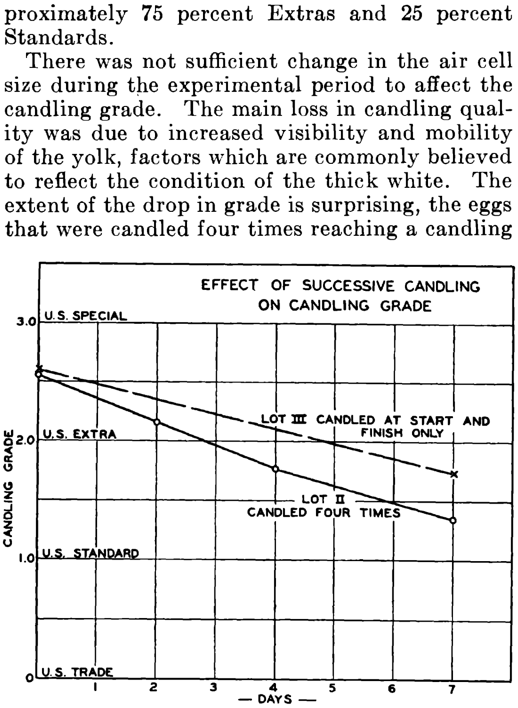

FIGURE 1.—Two intervening candlings reduced the apparent grade as much as 3 extra days in storage undisturbed.

TABLE 2.—*Interior quality measurements of eggs in the three lots*

Candling grade	Lot I (Control)			Lot II (Candled 4 times)			Lot III (Candled twice)		
	Eggs	Area of thick white	Quality[1]	Eggs	Area of thick white	Quality[1]	Eggs	Area of thick white	Quality[1]
	No.	*Sq. cm.*	*Percent*	*No.*	*Sq. cm.*	*Percent*	*No.*	*Sq. cm.*	*Percent*
Specials	40	43.9	104						
Extras	22	44.7	102	34	43.1	106	56	45.9	99
Standards				50	45.8	99	37	44.8	102
Total	62	44.3	103	84	44.8	101	93	45.5	100

[1] This measurement has been explained by the senior authors (*4*).

score of 1.36, or 42 percent Extras, 52 percent Standards, and 6 percent Trades. The eggs that were not candled during the intervening period, Lot III, showed markedly less drop in grade, scoring 1.74, or 8 percent Specials, 57 percent Extras, and 35 percent Standards. Thus these eggs showed at 7 days the same loss found in Lot II after 4 days in storage with one intervening candling.

The average interior quality in all three lots was found to be quite closely the same (table 2).

The changes in candling grade are not reflected in an increase in thick white area. This is especially noteworthy when it is remembered that the visibility and mobility of the yolk were the factors that changed during the course of the experiment. A second observation of importance is the high interior quality of eggs held at 30° F. for a week.

OBSERVATIONS ON STORAGE EGGS

An experiment was conducted on storage eggs, at the suggestion of Mr. Rob R. Slocum, in an effort to determine whether the changes in candling grade found shortly after removing eggs from storage was accompanied by a change in interior quality.

A case of white eggs graded as U. S. Extras and stored March 29, 1938, in commercial storage was candled at 30° F. on October 21, 1938. The eggs were divided into lots, one broken out immedi-

TABLE 3.—*Changes in candling grade of eggs, originally U. S. extras, stored for 7 months, and then warmed to 56°-58° F.*

Change in candling grade	Lot A		Lot B		Lot C			
	Warmed in 15 minutes		Warmed over night		Candled after warming over-night		Replaced in cold storage for 3 days and recandled	
	No.	*Percent*[1]	*No.*	*Percent*[1]	*No.*	*Percent*[1]	*No.*	*Percent*[1]
Drop in grade from—								
Extra to Standard	6	67	4	57	9	82	3	75
Standard to Trade	9	15	8	12	5	8	24	36
Raise in grade from—								
Standard to Extra	1	1	3	5	2	3	0	0
Trade to Extra	4	80	3	38	9	82	0	0

[1] The base is the full number assigned to the grade first named upon removal from storage and before any warming.

ately; one (lot A, table 3) was warmed in 15 minutes to 56-58° F.; one (lot B) was warmed overnight to this temperature, and one (lot C) was warmed overnight and after candling was replaced in the storage rooms for three days before recandling. The lots were candled and their interior quality measured by the same procedure as in the preceding experiment.

The candling data are presented in table 3, in which the changes in grade after the different treatments are shown.

There appeared to the candler to be a consistent loss in grade of about ½ grade in the eggs of better quality. The Extras, of course, were not top Extras, and therefore most of them fell out of grade. The Standards, having dropped from Extras during storage, were relatively good Standards upon the initial candling, and after being warmed showed a lower quality, but only about 10 to 15 percent fell out of grade.

The eggs that had been candled, warmed, candled, and chilled for three days showed a continuation of this trend, for 36 percent of the Standards fell out of grade then. A number of the Trades, on the other hand, definitely rose in grade due to candling. This was caused by the yolk, which had settled badly during storage, floating higher in the egg after one candling. The broken-out quality data on these eggs are not presented in detail, for the changes found were negligible; in no case was there a change greater than 10 percent. These changes in candling grade, without an accompanying change in interior quality, were observed on successive candling when the temperature had been raised and also when the eggs were chilled again. Any significant effect of temperature should have been apparent in the interior quality measurements. Therefore the effects observed can best be attributed to the effect of handling the eggs.

DISCUSSION

It has been observed that fresh eggs candled repeatedly lose candling grade thereby. This is presumably due to the shaking to which the egg is necessarily subjected, for the interior quality remains substantially the same. The question immediately arises as to whether or not the shaking incident to the transportation of eggs does not cause a similar effect, namely, a loss of candling grade. There are a number of observations in the grading experience of the junior author that substantiate this idea. From 50 to 90 percent of eggs that graded U. S. Specials were found after several hours on retail route delivery trucks to be in the next lower grade.

The lack of correlation between candling grade and the appearance of the eggs (interior quality) in *eggs of comparable history* was observed previously (*4*). However, in the careful work of Parsons and Mink (*6*) *on eggs of random history* a correlation was observed, especially toward the higher and lower limits of the classifications. It is believed that there is no conflict between these observations. Eggs of the different grades that are purchased in the market almost certainly reflect the treatment to which they have been subjected. Extras have probably had rather careful handling and temperature control from the nest, Standards have been less carefully kept, and Trades have had, in general, poor care. In such eggs of miscellaneous history the rather wide differences in care must be apparent in both the interior quality and candling grade. In eggs of *uniform history*, in which the changes in candling grade are produced primarily by changes in the *apparent* condition of the white before the candle, this *apparent* difference is not found in the white when the eggs are broken.

In storage eggs the decrease in grade after one candling was marked in eggs of higher quality, and a surprising number of Trades rose to Standards. This finding may be of some importance from a grading standpoint.

Other applications of such methods are obvious. The interior quality of eggs intended for storage must be high if a "top-quality storage" egg is to have an important place in the retail market. It is realized that sampling procedures are unsatisfactory as a general commercial practice in the industry. However, the periodical use of broken-out quality methods to check the care with which large producers handle their eggs, seems to the authors to be practical in the purchase of eggs for storage and for the top-quality fresh egg market.

SUMMARY

The changes in U. S. candling grade caused by holding strictly fresh eggs for one week at 30° F. were measured. Eggs candled at the beginning and after 7 days fell from 60 percent U. S. Specials to 75 percent U. S. Extras. Eggs candled at the beginning, on the 2nd, the 4th, and the 7th days fell from 60 percent U. S. Specials to 35 percent U. S. Extras. The interior quality, as measured by the area of the thick white, did not change appreciably during the week in either lot. Commercial storage eggs also lost grade each time they were candled. The eggs were candled, then warmed overnight to 56°–58° F., candled, then chilled again to 30° F. for 3 days and candled. Temperature changes alone did not affect the grade, but the shaking of the candling technique did. The area of the thick white did not show a significant change due to these treatments. Candling is the necessary method of grading in commercial practice, but results such as these indicate that interior quality measurements should be considered in establishing standard grades and in the control of commercial practice.

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INFLUENCE OF STARCH ON THE DEPOSITION AND COMPOSITION OF CHICKEN AND EGG YOLK FAT

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Cruickshank[1] (*1*) has shown experimentally that in the synthesis of chicken egg fat the hen exercises a selective influence and that there may be a degree of saturation of the fat which cannot be increased by the ingestion of saturated fatty acids but which can be reduced to a marked extent by the assimilation of unsaturated acids. Further, since the fat of egg yolk serves as a source of energy for the developing embryo, the fact that its composition can be materially influenced by certain nutritional factors may be of considerable significance in connection with embryonic nutrition and hatchability. She has also concluded from her experiments that the superficial and internal fat reserves may be varied in composition by the intake of the fatty acids, and that these reserve fats are quite uniform in composition.

Flock, Bollman, Hester, and Mann[2] have produced very large and fatty livers and greatly increased quantities of reserve fat by forced feeding geese on rations containing high percentages of carbohydrates. This fat was more saturated than normal, the liver fat being more saturated than the reserve fat, and among other things the iodine numbers of the fatty acids in the liver were lower than those of the reserve fat.

The authors[3] have previously shown that rations containing larger amounts of corn developed larger quantities of fat in Rhode Island Red chicks, and the chemical composition of the reserve fat of the various lots was materially changed. While the oil in the uropygeal glands of the chicks was materially different from that of the reserve fats, its composition varied less than that of the body reserve fat.

We are concerned in this experiment with the effect of rations containing varying quantities of starch on the quantity and character of reserve fat deposited in Rhode Island Red hens, and with the composition of the egg yolk and also with the number of eggs, weight of egg and egg shell, and the hatchability of the eggs.

The ingredients in the rations fed to four lots of Rhode Island Red hens are given in table 1, and the chemical composition of these rations are given in table 2. Four lots, each containing ten 1-year-old Rhode Island Red hens, were used in this experiment, which extended from December 9, 1937, to April 19, 1938. The hens came from the same parent stock and before being placed in batteries were found to be fat and in laying condition and had received the same ration, No. 1, for six weeks. The average weights of the hens in the four lots were approximately the same. The eggs from each hen in the four lots were weighed individually. Throughout the experiment alternately laid eggs from the hens were analyzed and the others were incubated. The weights of the dry shells, the wet and dry yolks and the percentage of fat in the dry yolk of the eggs analyzed were determined. The refractive index and iodine number of the extracted egg yolk fat were also determined.

TABLE 1.—*Composition of the mashes fed*

Ingredient	Lot 1	Lot 2	Lot 3	Lot 4
	Per-cent	*Per-cent*	*Per-cent*	*Per-cent*
Ground yellow corn	53.5	27.0	0.0	0.0
Mixed wheat feed	21.0	21.0	30.0	39.5
Distillers' corn dried grains	0	27.0	37.0	17.0
Soybean oil meal	4.0	4.0	6.0	8.0
Alfalfa leaf meal	2.0	2.0	3.0	4.0
Dried skimmilk	8.0	8.0	11.5	16.0
Meat scrap	6.0	6.0	8.5	12.0
Salt	1.0	1.0	1.0	1.0
Limestone	1.5	1.5	2.5	2.0
Bone meal	2.5	2.0	0	0
Cod liver oil concentrate	.5	.5	.5	.5

At the end of the experiment the hens were killed and the reserve fat was removed from each and thoroughly mixed. Previous experiments have shown that there were no material differences in the chemical character of the several reserve fats of hens. These reserve fats were weighed and their iodine number and refractive index determined.

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The average weights of the reserve fat in the hens in the four lots, which received rations containing 38.0, 21.0, 5.9, and 7.3 percents of starch, respectively, decrease in the same order, with the exception of lots 3 and 4 (table 3). The decrease in the quantity of fat in the hens in the lots receiving rations lower in starch compensates in a measure for the lower average weight of the hens.

TABLE 2.—*Analyses of the mashes fed*

Component	Lot 1	Lot 2	Lot 3	Lot 4
	Percent	*Percent*	*Percent*	*Percent*
Starch	38.0	21.0	5.9	7.3
Water	7.3	8.2	8.9	7.9
Protein	17.2	22.4	27.7	27.1
Fat	4.4	7.5	8.4	6.3
Fiber	3.3	7.0	8.0	6.6
Nitrogen free extract	63.6	50.6	42.7	47.1
Ash	4.2	4.3	4.3	5.0
Calcium	2.1	2.0	2.1	2.3
Phosphorus	1.0	1.1	1.0	1.2
Silica	.1	.2	.2	.2

TABLE 3.—*Comparative values of the four lots*

Lot	Average weight of the hens	Average weight of reserve fat in the hens	Reserve fat		Egg yolk fat	
			Average iodine number	Average refractive index	Average iodine number	Average refractive index
	Grams	*Grams*				
1	2486	282	78.9	1.4612	71.7	1.4667
2	2498	174	87.4	1.4610	72.0	1.4679
3	2298	71	87.4	1.4613	73.8	1.4672
4	2332	64	86.7	1.4610	73.6	1.4669

There is a material increase in the iodine number of the reserve fat of the hens in the lots receiving the rations lower in starch. The refractive indexes were not consistently altered by the rations used. The average iodine numbers of the egg yolk fat were lower than those of the reserve fat from the hens in corresponding lots, but showed less variation between the lots.

The following general conclusions are drawn from an examination of the data obtained concerning the eggs laid. The number and weight of the eggs, the weight of the dry egg shells, wet and dry yolk, percentage of fat in the dry egg yolk, and the hatchability of the egg did not materially vary because of the rations used.

SUMMARY

Rhode Island Red hens have been fed rations containing varying amounts of yellow corn and distillers' corn dried grains. The distillery by-product used contained less than 1-percent starch and approximately three times as much protein as corn when considered on a moisture free basis. Comparison has been made of the body reserve fat and egg yolk fat obtained from the hens.

The quantity of body reserve fat of the hens decreased with the percentage of starch in the rations. The percentage of egg yolk fat and the incubation of the eggs were not influenced materially by the starch content of the rations fed.

The composition of the egg yolk fat was influenced less by the rations than was the body reserve fat.

FACTORS AFFECTING THE MARKET QUALITY OF POULTRY MEAT[1]

By W. A. MAW, *Head of the Department of Poultry Husbandry, Macdonald College, Quebec, Canada*

The market quality of a group of poultry meat stock of similar breeding and age may vary widely. In ordinary commercial practice, the stock purchased may represent various breeds, birds varying in age, as well as stock with differences in the previous feed-treatment received, thus presenting a complicated problem for the feeder to handle in the finishing of such stock for dressing. It is, therefore, essential that all those concerned with the handling of such stock should have a full knowledge of the problems underlying these individual bird differences in growth, size at any particular age, body shape, amount of flesh on the body, and ability to feed to advantage in the station prior to dressing for market. A knowledge of the effect of different feeds upon the production of weight gains, as well as on the character of the fats produced, is also essential to economic practices.

BREED EFFECTS

The writer (*15*) has shown that apparent differences exist between the various pure breeds, Plymouth Rocks, Reds, Wyandottes, Orpingtons, Cornish, and Leghorns, as broilers or roasters, on the basis of the percentage of edible flesh on the fattened carcass. Certain of the cross-breds between these breeds excel over the pure breeds. Such differences, in certain cases, are due to the type of body represented, as well as to the weight

[1] Contribution from the Faculty of Agriculture of McGill University, Macdonald College, P. Q., Canada. Macdonald College Journal Series No. 122.

of bone in the body. Certain secondary sexual characteristics, such as weight of comb and wattles, also influence the relative proportion of flesh to the live weight in the different types. In later work, Maw and Maw (*20*), in studying the relationship of certain body measurements to the percentage of edible flesh in three breeds, found that no significant differences existed.

BODY SHAPE

In the grading of dressed carcasses, plumpness of fleshing throughout the body is essential to high quality. Fullness of muscular development is also basic to maximum fat production. However, the type of body found in many individuals may be such as to prohibit plumpness of muscle development. The length of the body in relation to its depth and breadth may be out of proportion, thus presenting a flat-sided carcass or, at least, an angular type of body.

Considerable variation in the skeletal size and shape of the body exists in strains of stock within a breed. The main aim of the poultry breeder should, therefore, be to control the body shape through breeding by the selection of the stock on a basis of skeletal proportions which give a high percentage of flesh to the weight of bone and waste parts. Maw and Maw (*19*) have shown that the body type in the sire used has a definite influence upon the body shape in the male progeny; relatively no influence on body shape was related to the dams used. Jaap and Penquite (*11*) have reported that there is a relationship between certain body measurements and weight which is an indication of body shape. Jaap (*10*) also suggested a standard maximum shank length, a minimum keel length, and a suggested body depth for varying body weights in a turkey stock. Payne (*26*) and Gutteridge (*4*) have worked out methods of measuring the breast area of the live bird to relate to body shape and to the percentage of flesh on the carcass.

Maw and Maw (*20*), in studying the relationship of body measurements to gains made during the fattening process, as well as to the percentage of flesh on the carcass, have found that certain body measurements are significantly correlated with gain. Regression studies have shown that where the length and depth of body are increased an increase in gain is made, whereas an increase in the length of leg or keel may result in smaller gains. These results suggest that a certain proportionate relationship in body skeletal measurements is essential to maximum fattening gains. The relationships between the body measurements and the percentage of flesh on the carcass were low. These results tend to show that an increase in the length of the body is related to a decrease in the amount of edible flesh.

All such developments indicate that the possibilities for the selection of stock to improve the body shape and the plumpness of fleshing in the carcass are within control. When body weight, for the breed represented, is kept in mind, there is reason to believe that the economic value of the stock is enhanced, since such selection for shape should not, in any way, be detrimental to egg production.

As shown by Maw and Maw (*19*), through an X-ray study of the skeletal development of the growing cockerel, the ultimate type or body shape of the individual can be determined with relative ease at twelve weeks of age.

A well-proportioned body in stock which is also being selected for such characteristics as early feathering and early maturity, with standard size for the breed, should produce better quality in the growing stock for meat purposes at any age.

AGE OF STOCK AS INFLUENCING CARCASS VALUE

Mitchell, Card, and Hamilton (*25*), in studying the growth of White Plymouth Rock chickens, have shown the relative increase of muscle over bone as growth advances; also, that the relative increase in the weight of the leg above the hock is greater in cockerels than in pullets. Maw (*17*) has also shown that, in Barred Plymouth Rock cockerel stock, the percentage of meat on the carcass increases with increasing age, and that the younger stock make more economical gains on the basis of the gain-feed ratio during fattening. Maturity of skeletal development in the body is, therefore, essential to maximum edible flesh on the carcass. From the standpoint of the feeder of meat stock, the younger birds make greater gains with less feed cost per pound gain. Where the stock is fed for 14 days, the younger stock will dress-out over 100 percent of the initial starved weight. On the other hand, the processor of dressed poultry will get the greatest percentage, as eviscerated stock, with mature-bodied or large-sized stock.

Schnetzler (*27*), in studying the inheritance of the growth rate in Barred Plymouth Rock chickens, found that the stock could be segregated at 8 or 9 weeks of age into fast- and slow-growing groups, the fast-growing group attaining the heaviest weight when mature. It should, therefore, be possible to combine the factors for body shape and fast growth, or body weight, and thus produce a more economical strain for meat qualities in an egg-production strain of stock.

METHOD OF HANDLING MEAT STOCK DURING THE FINISHING PROCESS

It has been pointed out by Jull and Maw (*13*), Maw (*16*), and Harshaw (*8*) that significant differences exist between range, or unfattened stock, and fattened stock in the percentage of edible meat on the carcasses. Halnan (*5*) has also reported the changes which take place in the edible portion of the carcass during the fattening process.

Various methods of handling meat stock during the finishing period have been used. It appears that the confinement methods are essential to the most economic results in producing a quality finish on the carcass. The softening of the muscle, as well as the production of a layer of fat over the muscle and inside the body, is the actual aim in the finishing work. These results may be attained in varying degrees by the different methods of handling in general use. Range-fattening is not generally used with poultry stock, although it may be used to advantage with certain classes of stock, if properly handled. The capon is one class of stock which may be satisfactorily finished on range. Slight changes in the method of feeding on range may be necessary to attain the desired changes in the character of the body fats, but such effects are possible with a quiet-natured bird such as the capon. Range-fed stock generally presents fuller muscling over the breast and legs.

With the pen-feeding method, where the stock is confined to pens, the birds will make fairly satisfactory gains, but not as efficiently as where handled in outdoor coops or in batteries indoors. Larger numbers of individuals are group-fed in pens than is the practice in battery feeding. The fact that more exercise is possible and that there is more interference by individuals at feeding time results in less economic gains for the feed consumed.

The outdoor coop, constructed like a battery, has good possibilities for the finishing of broilers. Groups of 16 to 20 individuals may be fed in single compartments. Apparently the out-of-door conditions have an effect upon the general reaction of the birds to confinement in coops or batteries.

Indoor battery handling of meat stock is, however, the only feasible method of handling commercial stock in large numbers. The control of environmental factors, which may have an effect upon the reaction of the birds to the changed feeding conditions, is at hand. Such factors as crowding, the segregation of stock into small groups, lighting in the feeding rooms, and possible disturbance of the stock while confined are all important to the feeding results in short-term feeding periods. The coop and the battery methods of handling the stock are, therefore, the most economical in all respects.

THE LENGTH OF THE FATTENING PERIOD

The length of the fattening period to be used for most economical returns is dependent upon a number of factors and cannot be specifically determined in a general way, in order to be adaptable to all the stock to be fattened. The age and the condition of the stock, as well as the ration to be fed, must be considered in determining the length of feeding period to be used. In commercial fattening, feeding periods of from 4 to 10 days in length are the usual practice, the average period being possibly 6 to 7 days. Experimental evidence, however, points to the general need for a period of over 7 days to attain the best results from most rations. These results are due largely to the wide variation found to exist between individuals in their reaction to the changed feeding methods and conditions. Maw (*17*) has shown that, with varying types of rations used with the various classes of stock, differences in the length of the feeding period have significant effects upon the gains made. Although apparent differences may be shown between rations, the differences shown in the gains made on the 7-day period may be entirely removed when the stock has been fed an additional 7 days, or 14 days in all. When the gains are adjusted for feed consumption, the differences shown on the short period may be considered as the result of the reaction of the birds to eating the different rations, which affects the amount of feed consumed or the effect of the ration in the body during the early part of the feeding period.

EFFECT OF DIET UPON GAINS AND MARKET QUALITY OF THE CARCASS

During the past few years numerous workers have been studying the effect of the diet upon the quality of the edible meats and fats. It is quite evident that rations of varying compositions have varying effects upon the gains made during the fattening period, as well as upon the character of the fats produced in the body. Halnan (*5*), Halnan and Cruickshank (*6*), Maw (*16*, *17*, *18*, *21*, *22*, *23*, *20*), Harshaw (*8*), Herner (*9*), Gutteridge (*3*), Halnan and Fermor (*7*), Aleinicoff (*1*), and Jeffrey (*12*) have all brought forth results demonstrating the effect of the diet upon the composition of the carcass. In many instances, the rations fed have produced more fat and less protein in the body of the chicken than was shown in the analysis of the feed. It is, therefore, evident that the carbohydrates of the feed are converted into body fats by the chicken. Numerous feeding trials have shown that only relatively simple rations are necessary for satisfactory fattening results. The rate of gain to be made is dependent, in part, upon the character of the ration fed and, also, upon other factors, such as the age of the stock and the length of the feeding period used.

Single or combined cereals may be used as the basic ration, to which should be added the necessary proteins, salt, and bleaching agents if desired. Maw et al. (*20*) have shown that, with certain classes of stock, some cereals do not produce an effect upon gain as quickly as do others. In such cases, longer feeding periods appear to be necessary. The resulting effects upon the quality of the carcasses, however, in certain cases, appear to be even better than with those cereals which produce immediate effects upon gain. Here the nature or composition of the ration plays an important part in affecting the deposition of fat, since the amount of fat produced is usually much greater than the amount of protein. Any possible effects of the diet on the distribution of the fats within the body are still questionable, although the results of some trials point in that direction.

The evidence brought forward regarding the value of supplementing the basic cereal feeds with proteins and fats has shown definite effects upon the gains made and upon the character of the fats produced, but relatively little effect upon the production of the fats. Such results indicate that only minimum additions of proteins and fats to the cereal basal ration are necessary for satisfactory results. The character of the added protein or fat to be used, however, may be selected on the basis of its influence upon the palatability and flavor of the cooked edible meats and fats. There are distinct differences in the palatability of meats produced by the different protein supplements. The same is true with the fats or oils used. Such differences may also be evident as a result of the feeding of certain cereal grains.

The effects of some of the supplementary feeds upon the flavor of the cooked meats may be such as to make their use prohibitive, in spite of their value in producing gains and apparent quality on the basis of the fats.

PHYSIOLOGICAL EFFECT OF ENDOCRINE PRODUCTS

Maw, Stuart, and Collip (*24*), in studying the effect of the anterior pituitary extract (622c) upon the deposition of fat in the cockerel, found that the extract increased the amount of abdominal fat, but greatly decreased the carotinoid pigment content of the fat. There was no apparent effect on the feed consumed, but a difference in gain in body weight was shown in favor of the injected birds.

CONCLUSION

Poultry meat stock, as received for finishing or as dressed, varies widely in body shape, fullness of fleshing, distribution of fat over and within the body, and edible quality of the flesh and fats, all of which may be traced to certain causes. The original selection of the stock for market quality, the method of finishing, the length of the period fattened, and the composition and the character of the ration fed, are factors which should be within control by the producer to insure economic production as well as to insure acceptable edible quality for the consumer.

SUMMARY

Numerous factors affect the physical and chemical composition of poultry meat stock. Those factors which affect the shape of the body, the amount of fleshing on the carcass, as well as the size or weight of the dressed carcass, are within the control of the poultry breeder or producer. The quality of the edible meat and fats is dependent upon the finishing process used, the composition and the character of the rations fed, the length of the feeding period, and, to some extent, the age of the stock or the stage of maturity at which it is dressed. Definite relationships exist between many of these factors, all of which are apparently within control.

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THE EFFECT OF COD-LIVER OIL AND FISHMEAL ON THE FLAVOR OF POULTRY PRODUCTS

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The occurrence of fishy odor and flavor in poultry products is a matter of considerable annoyance and economic loss to the consumer, and has been the subject of several investigations in regard to turkeys (*1*, *2*). Complaints of fishy flavors in chicken meat and especially in eggs are also occasionally encountered. Carrick & Hauge (*3*) report that 2 percent or 4 percent of cod-liver oil imparts a fishy taste to the flesh of chickens. A press release of the United States Department of Agriculture in December 1936 indicated that the feeding of fishmeals, particularly in conjunction with cod-liver oil, produced a fishy flavor in chicken carcasses.

Since cod-liver oil (often of a poor quality) and fishmeals of varying grade are largely used in England, it was thought of interest to ascertain whether the amounts of these substances commonly employed exert a detrimental effect on the flavor of the eggs and carcasses of Light Sussex chickens.

EXPERIMENTAL PROCEDURE

Experiments were designed to test the effects of the following supplements:

1. *One percent and two percent first grade cod-liver oil* fed during the fattening period only up to the time of killing. Birds off the range were used which had previously had no cod-liver oil. The rations used were as follows:

(1) Basal ration (88 percent ground cereal mixture, consisting of equal parts of corn (maize), oats and barley plus 12 percent dried skim milk).
(2) Basal ration plus 1 percent cod liver oil.
(3) Basal ration plus 2 percent cod liver oil.

The birds (16 weeks old) were fattened in batteries for 14 days. They were then starved for 24 hours, weighed, killed, and trussed. Three birds in each group were cooked fresh and subjected to palatability tests, and the same number was cooked and tested after 15 weeks in storage at $-10°$ C. Samples of body fat from each group were taken for chemical analysis.

2. *Two percent of* (*a*) *high grade cod-liver oil* (free fatty acid content 0.6 percent). (*b*) *second grade oil* (F.F.A. content 4.4 percent). Sixteen-week-old birds off the range were used, and these supplements were added to the fattening ration detailed above. Two birds in each group were cooked fresh and the same number after 15 weeks in storage at $-10°$ C.

3. *Different levels of* (*A*) *high grade and* (*B*) *low grade fishmeal plus cod-liver oil.* The scheme of procedure in this section was as follows:

Supplement	Period of feeding	Birds tasted fresh	Birds tasted stored	
			Stored 4 weeks	Stored 12 weeks
5 percent, 10 percent, and 15 percent fishmeal	4 weeks	9	......	6
Do	6 months	9	6	......
25 percent fishmeal	3 weeks	2	....	......

This scheme was carried out in duplicate, i.e., with fishmeal (A) and fishmeal (B). The 25 percent group was formed by taking two birds from the 10 percent A and two from the 10 percent B lots and raising the supplements to 25 percent for the last 3 weeks before killing. The basal ration consisted of:

	Percent
Sussex ground oats	30
Bran	20
Maize	30
Barley	11
Dried skim milk	5
Cod-liver oil (1st grade)	2
Calcium carbonate	2

To this ration the fishmeals were added at the levels indicated. No grain was fed. Fishmeal (A) contained 3.6 percent ether extract (iodine value 147) while fishmeal (B), which was the lowest grade of fish offal obtainable, contained 20 percent of ether extract (I.V. 154). The basal ration containing the 2 percent cod-liver oil contained 6.9 percent ether extract. The 5 percent, 10 percent and 15 percent (A) fishmeal mashes contained 6–7 percent ether extract, the corresponding (B) mashes 8–9 percent. The incorporation of the (A) fishmeal lowered the fat content of the mashes to a slight extent, since its fat content was lower than that of the basal mash. Even the 15 percent addition of the (B) meal raised the fat content of the mash only by about 2 percent. Except on the 5 percent (B) ration, growth was excellent in all groups, particularly in the 15 percent (A) group. Feathering was poor when 5 percent and 10 percent (B) fishmeal was fed, with the result that feather-picking was prevalent. The birds were starved, killed, and trussed as in section 1. Pullets and cockerels were used indiscriminately for the palatability tests. Samples of body fat from the basal group and from the 10 percent and 15 percent (A) and (B) groups (6 months feeding) were taken for chemical analysis.

Eggs from the 10 percent, 15 percent and 25 percent groups, both (A) and (B), were collected and tested for palatability. The yolk fat from the eggs produced on the basal and the 25 percent (A) and (B) rations was extracted for chemical analysis.

COOKING METHODS AND PALATABILITY TESTS

In sections 1 and 2 all birds subjected to palatability tests were roasted. Roasting was carried out in a gas oven at 350° F. for appropriate periods, according to carcass weight. In section 3 one bird of each group was steamed in an aluminum steamer, as it was thought of interest to investigate the effect of an alternate method of cooking. The remaining birds in this section were roasted.

Palatability tests were carried out by a panel of four tasters, experienced in the tasting of meat and bacon. It was found that by using expert tasters very good agreement between individuals was obtained. Breast muscle, thigh muscle, and skin were sampled for flavor, in that order, and the occurrence of fishy flavor reported as none, slight, or definite. Only three birds were sampled at each test, a control bird being also sampled at the same time. The birds were tested immediately after removal from the oven or steamer, without salt or accompaniment of any kind. The tasters freshened their palates with a slice of raw apple between samples.

Eggs for the palatability tests were soft boiled, and tasted while hot, without salt.

RESULTS

Palatability tests

It was found that in no case examined did the breast muscle show any indication of fishy flavor. When present, this was detected only in the thigh and in the skin.

1. *One percent and two percent first grade cod-liver oil, during fattening.*—No fishy flavor was noted in any of the birds, either fresh or stored, except in the skin of one individual of the 2 percent group after 15 weeks in storage at $-10°$ C.

2. *Two percent of (A) high grade and (B) second grade cod-liver oil, during fattening.*—There was no evidence of fishy flavor in any of the birds tested in this section.

3. *Different levels of (A) high grade and (B) low grade fishmeals plus cod-liver oil.*—In none of the (A) fishmeal birds either fresh or stored was a fishy flavor discernible. In the (B) fishmeal groups the thigh and skin of one bird (15 percent fishmeal for 4 weeks) cooked fresh was classed slightly but definitely fishy by all observers. In another bird of the same group, the skin was noted as slightly fishy by 3 of the 4 observers. One bird on the 10 percent (B) ration fed 6 months was classed as slightly fishy by all tasters. None of the stored birds examined in the (B) groups exhibited fishy flavor.

In order to economize space, the scores for flavor obtained in the foregoing sections have not been given in detail, as so many were negative.

4. *Eggs.*—Ten eggs from each of the 10 percent, 15 percent and 25 percent fishmeal groups were examined for fishy flavor. The results, expressed as percentages, are set out diagrammatically in figure 1. Yolks only were tasted, as the whites

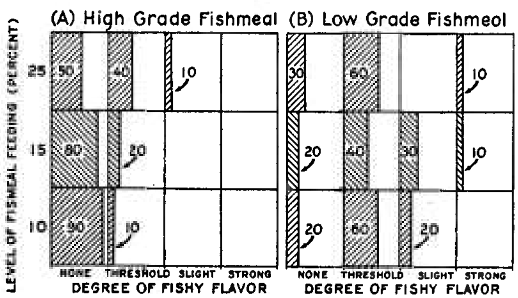

FIGURE 1.—Percentage distribution of fishy flavor in eggs from hens fed different levels of fishmeals.

were found to show no taint. The term "threshold" refers to a flavor which was designated somewhat strong, but could not be classed as fishy.

The diagram shows that the proportion of eggs which had no fishy flavor at all was markedly greater in the high-grade fishmeal groups. Only the 25 percent (A) eggs showed even a slight fishy taint. In the (B) groups on the other hand, the percentage of eggs with no fishy taint was relatively small, while a considerable percentage showed a threshold flavor; slight taint was found in a certain number of both the 10 percent and 15 percent groups, and a strong fishy flavor was noted in a small percentage of the 15 percent and 25 percent lots.

Analytical data

The iodine values and solid acid content of the mixed acids of the body fat of some of the experimental birds were estimated to ascertain whether the rations fed had materially affected the composition. The results are given below, together with the iodine values of the mixed acids of the yolk fat of the eggs from three groups of birds. These data show that by including cod liver oil in the fattening ration the iodine value of the body fat of fattened birds may be slightly raised above that produced on the basal ration alone, though the solid acid content remains practically constant.

In the fishmeal groups no consistent trend in the degree of unsaturation of the body fat is shown with increase in the fishmeal supplement, but when 15 percent (B) fishmeal is fed, the iodine value of the mixed acids is increased and the solid acid content somewhat lowered as compared with the other groups. It must be remembered that, as previously stated, even the incorporation of 15 percent (B) fishmeal (fat content 20 percent) in the basal ration raises the fat content of the ration only by about 2 percent, and therefore marked differences in the constants determined are not likely to be observed.

TABLE 1.—*Iodine values and solid acid content of body fat and of egg fat of experimental birds*

Fattening ration plus cod-liver oil

Ration	Mixed fatty acids		
	Body fat		Egg fat
	Iodine value	Solid acids	Iodine value
		Percent	
Basal ration	69.8	33.13	....
Do., plus cod liver oil:			
1 percent	72.2	33.25	....
2 percent	75.0	32.25	....
Fishmeal feeding for 6 months			
Basal ration	85.7	27.5	....
Do., plus (A) meal:			
10 percent	87.4	28.4	....
15 percent	85.3	28.2	....
Do., plus (B) meal:			
10 percent	87.8	27.5	....
15 percent	92.9	25.6	....
Fishmeal feeding for 3 weeks			
Basal ration	....	....	91.6
Do., plus (A) meal, 25 percent	....	....	91.69
Do., plus (B) meal, 25 percent	....	....	96.12

In the egg fat, no difference in iodine value is shown between the mixed acids of the eggs produced on the basal and 25 percent (A) rations. A supplement of 25 percent (B) fishmeal however, has slightly increased the iodine value.

DISCUSSION

From the palatability tests it appears that up to 2 percent of even a second grade cod liver oil may be included in the fattening ration without loss of quality in either the fresh or stored carcass. Under the conditions of the present experiment, when a good quality of fishmeal is fed at levels up to 15 percent up to the time of killing, no adverse effect on either the fresh or the stored carcass is likely to be observed. Even 25 percent fed for a 3-week period did not appear to affect it. When a poor quality of fishmeal is fed, there is some risk of the occurrence of fishy flavor with the higher levels, though this may appear in only a few cases. It was rather surprising to find that although slight fishy flavor was discernible in some of the fresh birds examined in the (B) groups, there was no evidence of it in the stored birds. A possible explanation is that there is a difference between individuals in the development of fishy flavor even on the same ration. Some of the birds receiving 15 percent low grade fishmeal for 6 months tended to have an oily flavor—but without any indication of fishy taint. This was noted mainly in the pullets, where fat deposition was greater than in the cockerels. There was a subtle difference—rather difficult to define—between the flavor of such pullet carcasses and those of pullets reared on the basal ration. It is conceivable, though this point has not been investigated, that these birds exhibiting an oily flavor, if left at room temperature for a time before being drawn and cooked would have developed an unpleasant flavor more readily than the control or the (A) fishmeal birds. It has been shown that the fat of pigs receiving considerable percentages of low grade fishmeal tends to become rancid very quickly (*4*).

The present experiments indicate that chicken meat is much less likely to possess a fishy flavor as the result of fishmeal and cod liver oil feeding than is turkey meat, which may exhibit fishy flavor when either 1 percent cod liver oil (not U.S.P.) or 10 percent white fishmeal is fed during growth up to killing. (*2*) In fishmeal-fed pigs, while fishy flavor is very frequently observed in the bacon, German workers (*5*) have found that the fresh pork from such animals shows no sign of fishy taint. The interesting fact emerged from their experiments, however, that the taint appeared in the liver, and was evident in the "leberwurst" made therefrom.

From the palatability tests it appears that the eggs are more likely than the carcasses to be detrimentally affected by feeding fishmeal, particularly low quality meals. In egg production rations low grade fishmeals and large amounts of high grade fishmeals should be avoided.

Reference to the analytical data shows that relatively little difference exists between the iodine value and solid acid content of the body fats within the various fishmeal groups. When these body fats are compared with the fats obtained from the fattened birds, however, it is seen that the former are all appreciably more unsaturated, indicating deposition of the fish oil acids. Although two of the groups of fattened birds were receiving cod liver oil, this was administered for only 14 days. Moreover, fat deposition was more rapid on the fattening ration than on the growth ration and therefore most of the fat laid down was formed from the carbohydrate of the diet (which produces a relatively hard fat) and was little influenced by the cod liver oil present.

It is evident from the palatability tests on the (A) groups that the deposition of a certain amount of highly unsaturated fish oil acids in the body fat is not necessarily accompanied by the presence of the substances responsible for fishy flavor. When the source of the acids is a low grade fishmeal, however, these substances may also be deposited in some cases, or may be produced during metabolism by the interaction of certain constituents in the meal.

The mixed fatty acids of the eggs examined show an iodine value of 90–96, which is considerably higher than that of eggs produced on a ration containing no fish oils, where the iodine value is about 80 (*6*). As in the body fat, therefore, the inclusion of fishmeals and cod liver oil in the diet leads to a deposition of unsaturated fatty acids in the egg fat. This change in composition is accompanied by a tendency towards fishy flavor, particularly when a low grade meal is fed.

SUMMARY

Two percent of cod liver oil in the fattening ration or 2 percent of best quality cod liver oil plus a 15 percent level of high grade fishmeal fed for a 6-month period up to the time of killing was without detrimental effect on the flavor of the carcasses, either fresh or stored, of Light Sussex chickens.

A 15 percent level of low grade fishmeal (fat content 20 percent) plus 2 percent of cod liver oil fed for a 4-week or 6-month period up to killing produced a slight fishy flavor in a few of the fresh carcasses though not in the stored carcasses. Individual differences in the development of fishy flavor on the same ration appear to exist.

Eggs from birds fed the higher levels of fishmeal plus 2 percent cod liver oil were more susceptible to fishy taint than the carcasses, especially with fishmeal of poor quality.

Prolonged feeding of rations containing fish oils causes an increase in the degree of unsaturation of both body fat and yolk fat.

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FLAVOR OF TURKEY MEAT AS AFFECTED BY FEEDING FISHMEAL AND FISH OIL[1]

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INTRODUCTION

Under some conditions of feeding and management, feeds of marine origin when fed to turkeys impart a definite flavor of fish to the meat. This fishy flavor in turkey carcasses has caused extensive loss to producers by the unfavorable reaction created among consumers. In order to avoid the production of turkey meat having a fishy flavor, many growers have discontinued the use of fish oil and fishmeal in the ration without realizing the extent of the loss of valuable proteins, minerals, and vitamins. Many byproduct feeds of the fish industry are important constituents of the ration since they supply a considerable portion of the necessary nutrients for satisfactory growth and bone development.

Only a limited amount of information has appeared in the literature concerning the problem, even though it is one of economic importance among turkey producers. Carrick and Hauge[3] reported that cod-liver oil, when fed in sufficient quantity, imparted a fishy taste to the flesh of

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[2] The authors wish to acknowledge the assistance of the Home Economics Department of The Pennsylvania State College in roasting the turkeys and in scoring the carcasses.

[3] Carrick, C. W., and Hauge, S. M. The effect of cod-liver oil upon flavor in poultry meat. Poultry Sci. 5:213-215. 1926.

chickens. A press release of the United States Department of Agriculture in December 1936 indicated that fishmeal and cod-liver oil, when fed separately or in combination, gave a fishy flavor to the meat of chickens and turkeys. Cosby and Knowlton[4] of the Oregon Agricultural Experiment Station have shown that certain grades and combinations of fishmeals and vitamin D oils when fed to turkeys will produce fishy or off-flavored carcasses when cooked.

Marble, Hunter, Knandel, and Dutcher[5] observed a fishy flavor and odor in the roasted carcasses of turkeys 28 weeks of age fed either 1 percent of a poultry-grade cod-liver oil (not U.S.P.) or 10 percent of vacuum-dried white fish meal, or both, during the entire growth period. A mash mixture containing these two ingredients when fed to turkeys produced a more pronounced flavor and odor than when fed separately.

These findings are not in accord with those of Asmundson and associates,[6] which indicate that a ration containing 25 percent of a high-grade fishmeal when fed to turkeys for 6 or more weeks prior to slaughter apparently did not produce an off-flavor in the meat. However, off-flavors and odors were observed in the carcasses of birds fed either 2 or 5 percent of fish oil and 25 percent of fishmeal.

In the work of Marble and coworkers[5] birds were removed from the groups fed either cod-liver oil or fishmeal or a combination of both, at 2, 4, and 8 weeks prior to slaughter and placed on a basal diet containing neither cod-liver oil nor fishmeal. Removal of both cod-liver oil and fishmeal from the diet 8 weeks before slaughter practically eliminated the occurrence of both fishy flavor and odor.

The object of the work here reported was to study the effect of various fish products used in turkey rations on the flavor of the meat produced, and to determine which products could be retained in the ration with minimum risk of imparting objectionable flavors and odors to the meat.

EXPERIMENTAL PROCEDURE

Day-old Bronze turkey poults hatched July 13, 1937, were fed for a period of 8 weeks an all-mash, 24-percent protein starting diet consisting of 28 pounds of ground yellow corn, 10 pounds of wheat bran, 10 pounds of standard wheat middlings, 10 pounds of ground heavy oats, 5 pounds of alfalfa leaf meal, 10 pounds of dry skim milk, 15 pounds of meat scrap, 10 pounds of white fishmeal, 1 pound of salt, and 1 pound of cod-liver oil.

At 8 weeks of age the poults were divided into six groups of 12 poults each. Each group was housed in a 10 by 12 foot colony brooder house with access at all times to a wire-covered sunporch. The houses were identically constructed and equipped. An all-mash diet containing approximately 20 percent of protein was fed from the eighth to the twenty-eighth week (table 1). The diet for each group was modified as follows:

TABLE 1.—*Composition of experimental diets*

Ingredient	Group No.—					
	1	2	3	4	5	6
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Ground yellow corn	31	30	30¾	30¾	31	31
Wheat bran	15	15	15	15	15	15
Standard wheat middlings	15	15	15	15	15	15
Ground heavy oats	10	10	10	10	10	10
Alfalfa leaf meal	5	5	5	5	5	5
Dry skim milk	5	5	5	5	5	5
Meat scrap	17	17	17	17	7	7
Ground limestone	1	1	1	1	1	1
Salt	1	1	1	1	1	1
Cod-liver oil (85 units of vitamin D)	0	1	0	0	0	0
Sardine oil (400 units of vitamin D)	0	0	¼	0	0	0
Cod-liver oil (400 units of vitamin D)	0	0	0	¼	0	0
Vacuum-dried white fish meal	0	0	0	0	10	0
Menhaden fish meal	0	0	0	0	0	10
Total	100	100	100	100	100	100

Group No.	Modifications in basal ration
1	None.
2	1 percent of a satisfactory grade of cod-liver oil, commonly used for animal-feeding, assaying 85 Association of Official Agricultural Chemists chick units of vitamin D per gram in place of 1 percent of ground yellow corn.
3	0.25 percent of sardine oil assaying 400 Association of Official Agricultural Chemists chick units of vitamin D per gram in place of 0.25 percent of ground yellow corn.
4	0.25 percent of cod-liver oil assaying 400 Association of Official Agricultural Chemists chick units of vitamin D per gram in place of 0.25 percent of ground yellow corn.
5	10 percent of vacuum-dried white fishmeal in place of 10 percent of meat scrap.
6	10 percent of menhaden (dark) fishmeal in place of 10 percent of meat scrap.

At 28 weeks of age, one male and one female from each of the 6 groups, or 12 birds in all, were starved for a period of 24 hours and then slaughtered, dry-picked, drawn, and quick frozen. The carcasses were held in a frozen condition for a period of 2 weeks. Each of 12 carcasses was then removed and roasted in a separate oven at a

[4] COSBY, H. E., and KNOWLTON, F. L. Third Progress Report on Fishy Flavored Turkeys. Oreg. Agr. Expt. Sta. (Unpublished data.)

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temperature of 325° F. No filling or seasoning was used. During the roasting period each turkey was frequently basted in its own juice. The giblets of each bird were boiled in separate containers.

On removal from the oven, each carcass was scored individually for fishy flavor and odor by 20 persons. The identity of the carcasses was not disclosed to those who assisted in their preparation nor to those who participated in the scoring. The tasters did not discuss their observations with one another until after the scoring had been completed. Odor of each carcass and flavor of the breast meat, thigh meat, giblets, and drippings were observed in the order named. Each person indicated the degree of flavor and odor of fish as none, slight, medium, or strong.

In place of a fork, a new toothpick was used each time a piece of meat was tasted. Clean glass stirring rods were used for tasting the drippings. To destroy the flavor between samples tasted, each person ate a small piece of dry bread and drank black coffee before proceeding to the next sample. A new paper cup was used for each serving of coffee. Every precaution was taken to avoid the possibility of the flavor of one sample influencing the flavor of another. Since, in previous work, a close correlation existed between the scorings of hot and cold meat, all carcasses were scored only while the meat was hot.

RESULTS AND DISCUSSION

It is realized that taste and smell are senses which are very difficult to measure quantitatively. Variation was found to exist in the taste reaction of different individuals. In order to overcome this variation as many tasters as feasible were used. Imagination seemed to influence the decision of some tasters, who reported fishy flavor and odor in carcasses of turkeys fed the basal diet containing neither fishmeal nor oil. Others did not detect either the flavor or odor of fish in samples in which both were very apparent to most tasters. However, the scores of all individuals who participated in the scoring of the carcasses are included in tables 2 and 3.

A greater degree of fishy flavor was observed in the dark meat than in the white meat. In the drippings the fishy flavor was more pronounced than in the meat. This was true for all five groups in which a substitution had been made in the basal diet. These observations are in accord with those of Marble and associates.[7]

The distribution of scores recorded by 20 observers on the flavor of the breast meat, thigh meat, giblets, and drippings is shown in table 2. Table 3 presents the distribution of scores on the odor of the entire carcass. One percent of cod-liver oil of a grade commonly used for animal feeding, when fed in a ration without fishmeal to turkeys for a period of 20 weeks previous to time of slaughtering, imparted to the meat a definite fishy flavor and odor. One-fourth of 1 percent of a high-potency vitamin D oil was fed in a ration without fishmeal to each of two groups of turkeys. These high-potency oils supplied to the ration practically the same number of units of vitamin D as 1 percent of the 85 unit cod-liver oil. The carcasses of turkeys fed one-fourth of 1 percent of high-potency oil were practically free from any flavor or odor of fish.

A slight flavor and odor of fish were detected in the carcasses of turkeys fed a ration containing either 10 percent of menhaden (dark) fishmeal or 10 percent of vacuum-dried white fishmeal. Ten percent of menhaden fishmeal in a ration without fish oil seemed to impart a slightly stronger flavor and odor than vacuum-dried white fishmeal.

[7] See footnote 5.

TABLE 2.—*Distribution of scores made by 20 observers for fishy flavor in the cooked meat of 28-week-old turkeys*

Substitutions in basal ration[1]	Scores for female turkeys showing indicated degree of fishy flavor				Scores for male turkeys showing indicated degree of fishy flavor			
	None	Slight	Medium	Strong	None	Slight	Medium	Strong
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Breast meat								
None	20	0	0	0	20	0	0	0
1 percent cod-liver oil	11	5	4	0	16	3	0	1
0.25 percent sardine oil	20	0	0	0	19	1	0	0
0.25 percent cod-liver oil	20	0	0	0	18	2	0	0
10 percent white fishmeal	18	2	0	0	19	1	0	0
10 percent menhaden fishmeal	18	1	1	0	20	0	0	0
Thigh meat								
None	20	0	0	0	19	1	0	0
1 percent cod-liver oil	7	4	6	3	13	5	1	1
0.25 percent sardine oil	19	1	0	0	15	5	0	0
0.25 percent cod-liver oil	19	1	0	0	15	5	0	0
10 percent white fishmeal	15	3	2	0	15	5	0	0
10 percent menhaden fishmeal	17	2	1	0	15	4	1	0
Giblets								
None	20	0	0	0	17	3	0	0
1 percent cod-liver oil	10	5	2	3	16	2	2	0
0.25 percent sardine oil	18	2	0	0	16	3	1	0
0.25 percent cod-liver oil	19	1	0	0	15	4	0	1
10 percent white fishmeal	15	3	2	0	15	5	0	0
10 percent menhaden fishmeal	12	7	1	0	15	3	2	0
Drippings								
None	19	1	0	0	14	5	1	0
1 percent cod-liver oil	3	3	6	8	9	4	5	2
0.25 percent sardine oil	15	3	2	0	14	3	3	0
0.25 percent cod-liver oil	19	1	0	0	11	6	3	0
10 percent white fishmeal	10	6	3	1	11	4	3	2
10 percent menhaden fishmeal	9	7	4	0	8	6	5	1

[1] Fed for a period of 20 weeks before slaughtering.

Carcasses of turkeys fed 1 percent of cod-liver oil exhibited a more pronounced fishy flavor and odor than did those fed 10 percent of either white or dark fishmeal.

At 28 weeks of age all turkeys on experiment were examined and the conformation of the breastbone noted. The breastbone of each bird was classified as straight or as one of three arbitrarily chosen degrees of deformity, namely, very deformed, deformed, and slightly deformed. Table 4 gives a summary of these observations. From a limited number of observations there was evidence to indicate that the retention of a source of vitamin D in the ration during the period of growth had a beneficial effect on the conformation of the breastbone.

TABLE 3.—*Distribution of scores made by 20 observers for fishy odor in the cooked meat of 28-week-old turkeys*

Substitutions in basal ration[1]	Scores for female turkeys showing indicated degree of fishy odor				Scores for male turkeys showing indicated degree of fishy odor			
	None	Slight	Medium	Strong	None	Slight	Medium	Strong
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
None	20	0	0	0	13	7	0	0
1 percent cod-liver oil	1	7	6	6	10	4	5	1
0.25 percent sardine oil	13	7	0	0	14	4	2	0
0.25 percent cod-liver oil	19	1	0	0	10	7	3	0
10 percent white fishmeal	9	9	2	0	12	7	1	0
10 percent menhaden fishmeal	8	10	2	0	9	9	1	1

[1] Fed for a period of 20 weeks before slaughtering.

TABLE 4.—*Effect of vitamin D in the ration on conformation of breastbone of 69 turkeys 28 weeks of age*

Groups	Turkeys having indicated breastbone conformation			
	Straight	Slightly deformed	Deformed	Very deformed
	Number	*Number*	*Number*	*Number*
Fed vitamin D:				
No. 2	10	2	0	0
No. 3	11	1	0	0
No. 4	7	1	1	2
Total	28	4	1	2
Fed no vitamin D:				
No. 1	6	4	0	1
No. 5	7	0	1	3
No. 6	7	2	1	2
Total	20	6	2	6

SUMMARY

Under some conditions of feeding and management, feeds of marine origin when fed to turkeys impart a definite flavor of fish to the meat. This fishy flavor in turkey carcasses has caused extensive loss to producers by the unfavorable reaction created among consumers. In order to avoid the production of turkey meat having a fishy flavor, many growers have discontinued the use of fish oil and fishmeal in the ration without realizing the extent of the loss of valuable proteins, minerals, and vitamins. Many byproduct feeds of the fish industry are important constituents of the ration since they supply a considerable portion of the necessary nutrients for satisfactory growth and bone development.

The object of the work here reported was to study the effect of various fish products used in turkey rations on the flavor of the meat produced and to determine which products could be retained in the ration as sources of protein, minerals, and vitamins with minimum risk of imparting objectionable flavors and odors to the meat.

Twelve carcasses of turkeys fed different fish products for varying periods of time were roasted in separate ovens. The degree of fishy flavor in the breast meat, thigh meat, giblets, and drippings was determined by 20 observers. The degree of fishy odor also was determined for all carcasses.

Carcasses of turkeys 28 weeks of age which had received a ration containing 1 percent of cod-liver oil but no fishmeal for a period of 20 weeks prior to slaughter exhibited a pronounced fishy flavor and odor when cooked. When 0.25 percent of either of two high-potency vitamin D oils was fed in a ration without fishmeal to turkeys of the same age and for the same period of time, carcasses were produced which when roasted were practically free from any flavor or odor of fish.

Evidence was obtained which indicated that a slight flavor and odor of fish were present in the carcasses of turkeys fed a ration containing either 10 percent of menhaden (dark) fishmeal or 10 percent of vacuum-dried white fishmeal. Ten percent of menhaden fishmeal appeared to impart a slightly stronger fishy flavor and odor than vacuum-dried white fishmeal. Carcasses of turkeys fed 1 percent of cod-liver oil exhibited a more pronounced flavor and odor than did those fed 10 percent of either white or dark fishmeal.

Limited evidence was obtained which indicated that retention of a source of vitamin D in the ration throughout the growing period influenced favorably the production of straight breastbones.

THEORIE DER JUNGGEFLÜGELMAST

Von Prof. Dr. Franz Lehmann, *Göttingen, Deutschland*

Es gibt 3 Arten der Mast, die nach der Zusammensetzung der Lebendgewichtszunahme charakterisiert werden können. Die Mast volljähriger Tiere liefert wenig Fleisch und viel Fett, so bei Rindern und Schafen etwa in einem Kilogramm: 200 g Fleisch, 800 g Fett.

Diese Mast ist fast nur Qualitätsverbesserung, gilt für alte Tiere, die ihre Dienste getan haben, so auch bei Legehennen. Allein eine rationelle Tierhaltung der Zukunft wird sie durch eine kräftige Schlussfütterung, ohne dass die Produktion sistiert wird, ersetzen.

Die 2. Methode ist die Mast des wachsenden Tieres. Hier enthält ein Kilogramm Zunahme:

	Fleisch *g*	Fett *g*	Asche *g*
bei Schweinen	505	473	22
bei Rindern	606	351	43

Fleisch und Fett sind ungefähr · in gleicher Menge vorhanden.

Das wachsende Tier ist der Fleischproduzent. Dann muss in der Zunahme umso mehr Fleisch erzeugt werden, je jünger das Tier ist.

Dies führt zu der 3. Art der Mast: der Jungtiermast. Als Beispiel:

	Fleisch *g*	Fett *g*	Asche *g*
Kalb mit Vollmilch gemästet	794	171	35
Spanferkel, 10 Wochen alt	749	220	31

Die Junggeflügelmast, über die hier berichtet wird, gehört in diese Klasse. Die folgenden Zahlen stammen aus Schlachtversuchen, die mit Mastversuchen kombiniert waren, und an Enten, Gänsen, 5 Hühnerarten und Puten angestellt sind. Durchweg begannen sie mit Küken, die 8 bis 14 Tage alt waren. Alle Ergebnisse wurden in Abschnitte von je 4 Wochen geteilt, am Ende jedes Abschnittes sind Tiere analysiert worden. Die Mast währte meistens 3 × 4 Wochen, Als Zunahmen wurde je Kilogramm gefunden:

	Fleisch *g*	Fett *g*	Asche *g*
Hühner, im Mittel von 5 Rassen			
1. Vierwoche	92.3	4.4	3.3
2. Vierwoche	89.0	6.6	4.4
3. Vierwoche	84.4	10.1	5.5
Enten			
1. Vierwoche	81.1	15.5	3.4
2. Vierwoche	76.3	18.5	5.2
Gänse			
1. Vierwoche	89.5	7.1	3.4
2. Vierwoche	73.8	21.6	4.6

Das ist das gleiche Bild wie die vorhin für Kalb und Ferkel gegebenen Zahlen. Allein es zeigen sich Unterschiede. Alle Hühnerrassen, und so auch die Puten haben ein mageres Fleisch, und von Fett gerade so viel, wie man in einem guten Braten schätzt. Gänse dagegen, und noch mehr die Enten geben von Anfang an ein fettreiches Fleisch. Da als Fleisch hier die Summe von Wasser und Stickstoffsubstanz bezeichnet wird und letztere getrennt ermittelt ist, lässt sich eine bekannte Gesetzmässigkeit kontrollieren: Der Gehalt der Trockensubstanz im Fleisch nimmt mit dem Lebensalter zu. So hat das Fleisch der 2 Wochen alten Hühnerküken, federfrei, im Mittel aller Versuche 17.8 Prozent Trockensubstanz, am Ende der ersten Vierwoche 20.0 Prozent und steigt mit der 2. Vierwoche auf 21.2 Prozent, am Ende der 3. Vierwoche 22.2 Prozent.

Parallel mit diesen Schlachtversuchen liefen Ermittlungen über Futterverzehr und Gewichtszunahme, die erlauben, Stoffwechselgleichungen aufzustellen. Als Modell diente ein älterer Versuch mit wachsenden Schweinen, dessen besonderer Wert darin lag, dass er mit einer genügend grossen Anzahl von Tieren durchgeführt ist. Denn es wurden beim Beginn des Versuches 4 Ferkel im Gewicht von 22 Kilogramm und am Schluss nach 20 wöchiger Schnellmast 18 Schweine in 3 Abteilungen zu je 6 Tieren geschlachtet, zerlegt und analysiert. Das Ergebnis der ganzen Untersuchung lässt sich in die Stoffwechselgleichung zusammenfassen, welche je Tag und Tier lautet: 310 g Eiweiss, 46.8 g Fett, 1460 g Kohlehydrate, zusammengefasst: 1880 g Gesamtnährstoff, gaben in 643 g Lebendgewichtszunahme 73 g Eiweiss, oder zusammen mit dem Wasser 323 g Fleisch, 307 g Fett und 14.5 g Asche.

Der Erfolg der Junggeflügelmast lässt sich an dem bei der Schweinemast gefundenen Zahlen beurteilen. Ein Schwein braucht in 140 Tagen bei genügender Menge von Eiweiss (40 kg) im ganzen 263 kg Gesamtnährstoff und erzeugt daraus 90.2 kg Zunahme mit: 45.2 kg Fleisch, 43.0 kg Fett, 2.0 kg Asche. Aus der gleichen Nährstoffmenge können 69 Rhodeländer Hühner gemästet werden. Sie bringen 96.6 kg Zunahme, worin enthalten sind: 85.6 kg Fleisch, 6.8 kg Fett, 4.2 kg Asche. Oder 50 Enten = 91 kg Zunahme mit: 67.0 kg Fleisch, 14.2 kg Fett, 3.5 kg Asche. Ebenso liefern 24 Puten 93.1 kg Zunahme, oder 27 Stück Mechelner Hühner (Brüsseler Poularden) 80.7 kg Zunahme.

Alles in allem zeigt diese unvollständige Skizze, wie stark die Junggeflügelmast in der Fleischproduktion der Schweinemast überlegen ist. Zugleich aber die unerwartete Tatsache, dass Junggeflügel aus der gleichen Futtermenge eine der Schweinemast durschschnittlich gleiche Lebendgewichtszunahme erzielt.

Diese Kongruenz findet ihre Erläuterung in der Verwertungszahl. Sie gibt an, wieviel Gesamtnährstoff nötig ist, um 100 Teile Zunahme zu erzeugen. In den 5 Vierwochen der Schweinemast steigt sie dauernd an:

	Vierwoche				
	1.	2.	3.	4.	5.
Verwertungszahl	210	230	261	300	335

und **beträgt** im Mittel der ganzen Mast 272. Jenseit 300 wird **die** Mast in der Regel Verlust bringen. Genau das **Bild** zeigt die Junggeflügelmast:

	Vierwoche			
	1.	2.	3.	4.
Rhodeländer	210	264	354	....
Orpington	160	253	355	437
Mechelner	181	268	293	390
Puten	186	262	306	407
Enten	181	369	....	....
Gänse	146	300	....	....

Im Mittel der ganzen Mast liegen die Verwertungszahlen zwischen 267 und 286 mit alleiniger Ausnahme der Gänse, die mit 225 die beste Futterverwertung bieten. Die Zahlen der Hühnerarten sind fast einheitlich. Beachtenswert ist das Verhalten der wertvollsten Mastrasse, der Mechelner, welche die hoch geschätzte Brüsseler Poularde in 3 oder 4 Vierwochenmast liefern. Parallel hiermit läuft die Linie der Puten. Dagegen zeigen Enten und Gänse auch hier ein abweichendes Bild. Es hängt mit der Schnellwüchsigkeit zusammen.

Wiederum empfiehlt sich ein Vergleich mit der Schweinemast, wenn das Anfangsgewicht und die Endgewichte jeder Vierwoche zusammengestellt und dann die Steigerung in der Weise berechnet wird, dass das Anfangsgewicht gleich 100 gesetzt wird.

Anfang	Vierwoche				
	1.	2.	3.	4.	5.
kg	*kg*	*kg*	*kg*	*kg*	*kg*
22.2	35.3	52.1	71.9	92.6	112.2
100:	159	235	324	417	506

Dagegen beim Junggeflügel (im Mittel aller Versuche) in g:

	Anfang	Vierwoche			
		1.	2.	3.	4.
Rhodeländer	53	377	904	1463	....
Orpington	52	391	990	1552	2034
Mechelner	78	534	1278	2069	2794
Puten	169	718	1834	2930	4050
Enten	67	1230	2207	....	....
Gänse	203	2173	4229	....	....
oder in Vielfachem des Anfangsgewichts:					
Rhodeländer	100:	712	1706	2761	....
Orpington	100:	752	1904	2985	3912
Mechelner	100:	685	1639	2653	3583
Puten	100:	452	1085	1734	2397
Enten	100:	1840	3290	....	....
Gänse	100:	1070	2080	....	....

Die ausserordentlich grosse Wachstumsgeschwindigkeit des Geflügels kommt hier für den Spezialfall abundanter Ernährung drastisch zum Ausdruck

Allein alle Jungtiermast ist zeitlich begrenzt und ihr Ende zu erkennen, darum von praktischer Wichtigkeit.

Es genügt zur Erläuterung, den Verlauf der Mast an einem Beispiel zu zeigen. Junggänse wurden im Alter von 2 Wochen und mit einem Gewicht 203 g je Stück zur Mast aufgestellt. Futterverzehr und Zunahme je Tier und Tag waren im Mittel jeder Woche in Gramm:

	Woche							
	1.	2.	3.	4.	5.	6.	7.	8.
Gesamtnährstoff	45	85	129	152	187	225	243	224
Zunahme	37	64	87	93	92	80	77	45
Verwertungszahl	121	133	148	164	203	283	317	495

Anfangs sprunghaftes Ansteigen im Futterverzehr, dann Zögern, und in der letzten Woche Abnahme. Dies ist das Zeichen, dass die Mast Abgebrochen werden muss und die letzte Verwertungszahl beweist es. Die Tiere haben zu dieser Zeit ihren Körper längst nicht völlig aufgebaut, aber sie sind "ausgemästet." Diese Grenze ist je nach Tierart und Rasse verschieden. Aufgabe des Versuches ist es, sie zu ermitteln. Bei Jungschweinen liegt sie etwa bei der 20. Mastwoche, Gänse und Enten sind bereits mit 8 Wochen ausgemästet. Rhodeländer, Orpington und andere mittelschwere Hühnerrassen mit 12 Wochen, Puten verlangen je nach Gewicht 12–16 Wochen, bei den schwersten Masthühnern, den Mechelner und ähnlichen Rassen lohnt es 18 Wochen zu mästen.

Gänzlich anders gestaltet sich das Bild, wenn Aufwand und Effekt der Mast in Kalorien ausgedrückt wird. Nach der Stoffwechselgleichung des Schweines ist bei dem Durchschnittsgewicht von 66.3 kg der Wärmewert der verdaulichen Nährstoffe des Futters je Tag 7902 Kal., die Produktion von Fleisch und Fett ergibt 3331 Kal. Es beträgt also die Ausbeute in Kal 42.2 Prozent. Die Differenz, also der unproduktive Teil des Futters, der nur als Wärme erscheint, ist 4571 Kal. Er kann "Leerlauf" genannt werden, ist aber nicht mit Grundumsatz gleich zu setzen. Zum mindesten muss hier der Arbeitsaufwand für die Assimilation des Stoffansatzes mit 829 Kal. abgezogen werden, so dass der Grundumsatz auf 3742 Kal. zu schätzen ist.

Das Junggeflügel verhält sich hier gänzlich anders. Die Ausbeute in Kal. beträgt für die ganze Mastzeit, also 3 Vierwochen bei den Hühnern einschliesslich der Puten nur 13.9 Prozent mit geringfügigen Einzelabweichungen und ist auch in den einzelnen Vierwochen nahezu gleich:

	Ausbeute in Kal. Prozent			
	Vierwoche			Mittel
	1.	2.	3.	
Hühner	14.9	14.0	13.2	13.9
Gänse	9.9	15.2	....	12.9
Enten	18.1	9.5	....	13.4

Gänse und Enten sind im Mittel trotz ihrer höheren Mastfähigkeit von den Hühnern kaum verschieden, verhalten sich aber in ihren 2 Vierwochen anders. Bei der Gans: Steigerung, bei der Ente dagegen: starke Senkung der Ausbeute in der 2. Masthälfte. Enten fallen immer durch ihre Gefrässigkeit als Küken auf, sie kommt auch in dieser Ausbeute zum Ausdruck.

Der geringen Ausbeute entsprechend ist der Leerlauf bei allen Geflügelarten prozentisch ungewöhnlich hoch. Er lässt sich auch je Kilogramm Lebendgewicht berechnen und beträgt dann im Mittel aller Hühnerarten für die einzelnen Vierwochen in Kal.

1. Vierwoche	2. Vierwoche	3. Vierwoche
82.4	65.3	44.3

dagegen auf ein Quadratmeter Oberfläche in Kal.

2073	2258	1989

Das Oberflächengesetz kommt hier deutlich zum Ausdruck. Die Zahlen zeigen trotz ihrer Abweichung, dass das Tier im Wärmehaushalt von der Oberfläche abhängig ist.

Das Studium der Junggeflügelmast bis zur Aufstellung der Stoffwechselgleichungen ist biologisch deshalb von Interesse, weil es die Entwickelung des Tierkörpers bei reichlicher Nahrung zeigt.

In der Praxis wird sich niemand durch die Konstatierung der geringen Kalorienausbeute stören lassen, denn die hier geschilderte Junggeflügelmast liefert nicht nur das meiste, sondern auch in der Qualität beste und höchst geschätzte Fleisch und ist im Futterverbrauch nicht teurer als die Schweinemast.

ZUSAMMENFASSUNG

Die Göttinger Methode der Jungschweinemast (20 kg bis 110 kg in 20 Wochen) ist seit 1922 auf die Geflügelmast angewandt worden. Der Bericht fasst die Versuche zusammen, die mit Enten, Gänsen, 5 Hühnerrassen und Puten angestellt sind.

Gemästet wird in allen Fällen vom Küken an bis zur Schlachtreife. Dauer der Mast 3 mal 4 Wochen. Haltung nicht in Käfigen, sondern in Ställen bei beschränktem Auslauf. Alle Ermittlungen endigten mit Schlachtversuchen, wodurch die Angabe der Ausbeute an Fleisch und Fett und die Aufstellung von Stoffwechselgleichungen ermöglicht wird. Solche Gegenüberstellungen der Nährstoffe im Futteraufwand und der Produktion sind für jede Vierwoche und für die ganze Mast berechnet.

Einige Ergebnisse: Junggeflügel liefert in der Gewichtszunahme hauptsächlich Fleisch. So Hühner 90 Prozent, Enten und Gänse 80 Prozent. Der Fettgehalt steigt mit jedem Altersmonat, geht aber bei Enten und Gänsen nicht über 20 Prozent hinaus und erreicht bei Hühnern nur 10 Prozent. Die ausserordentliche Schnellwüchsigkeit, die mit der des wachsenden Schweines verglichen wird, macht das Junggeflügel zum besten Fleischproduzenten. Doch ist die Mastmethode zeitlich begrenzt. Schweine bringen jenseits 20 Mastwochen Verlust, bei Junggeflügel liegt die durch Versuche scharf ermittelbare Grenze bei 12 bis 16 Wochen Mast. In Kalorien und bei allen Tierarten Übereinstimmung bezüglich der Ausbeute, des Leerlaufs, also des unproduktiven Anteils der Futterstoffe und in den Beziehungen des Leerlaufs zur Oberfläche des Körpers. Es lässt sich die Gültigkeit des Oberflächengesetzes auch für diesen Spezialfall der Tierhaltung, die abundante Ernährung, erweisen.

SUMMARY

The Göttingen method of fattening young hogs (20 kg to 110 kg in 20 weeks) has been extended to forced feeding of poultry since 1922. This paper gives a summary of the experiments which were carried out with ducks, geese, five breeds of chickens, with turkeys. In all cases chicks were fed till ready for slaughter. The time of forced feeding was three 4-week periods. The birds were not kept in cages, but in pens with restricted runs. All experiments were concluded at slaughter, which made possible the determination of the yield of flesh and fat and the setting up of metabolic quotients. Such comparisons between the nutritive substances in the feed consumed and production are calculated for each 4-week period, as well as for the entire time of forced feeding.

Young poultry furnish primarily flesh in their weight increase, chickens 90 percent, ducks and geese 80 percent. The fat content rises with each month of age, but it does not exceed 20 percent in ducks and geese and reaches only 10 percent in chickens. The extraordinarily rapid rate of growth, when compared with young hogs, makes young poultry the best meat producer. However, the forced feeding method is limited in time. Hogs bring losses after the twentieth week of fattening; in young poultry the precise experimentally determinable limit is between 12 and 16 weeks of feeding.

In calories, the metabolic quotient in all experiments and in all species shows correspondence with respect to yield, waste, that is, the unproductive component of feed, and with respect to the relation of waste to body surface. The validity of the law of surfaces could be demonstrated for this special case of animal husbandry, that of abundant feeding.

WEITERE UNTERSUCHUNGEN ZUR TECHNIK DER MAST JUNGER ENTEN

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Im Anschluss an frühere Untersuchungen (Kongressbericht I, VI. Weltgeflügelkongress 1936, S. 328–331) wurden im Frühjahr und Sommer 1938 weitere Versuche angesetzt, in denen Pekingenten nach gleichartiger Vorfütterung mit dem 10. Lebenstag in Freilandgehegen mit Zugang zu einer kleinen Wasserfläche zur Mast gestellt wurden. Während der Nacht und an regnerischen, kalten Tagen erfolgte die Unterbringung der Enten in einer Stallung, nach Bedarf unter Zuhilfenahme elektrisch beheizter Glueken, die die jungen Enten vor allem im Frühjahr gern aufsuchten. In allen Gruppen wurde das Mastfutter in niedrigen Trögen zu täglich fünf Futterzeiten gereicht. Die Untersuchung der einzelnen Futtermittel führte zu folgendem Ergebnis:

Tabelle 1

Futtermittel	Trocken-substanz	verdaul. Reineiweiss	Gesamt-nährstoff	Ballast
	Prozent	*Prozent*	*Prozent*	*Prozent*
Gerste	86.5	10.7	67.2	14.9
Mais	86.8	9.3	78.4	12.8
Weizenkleie	88.2	8.5	52.4	27.2
Zuckerschnitzel	92.0	1.1	66.7	10.6
Dorschmehl	88.4	54.3	65.1	9.0
Fleischmehl	91.4	54.0	70.9	8.0
grüne Luzerne	19.3	1.5	6.7	9.4
Kartoffelflocken	87.6	6.0	78.8	3.3
Sauerkartoffeln	22.8	1.1	17.0	1.2

Versuch A. Untersuchungen über die Einwirkung einer Aenderung des Eiweissverhältnisses des Mastfutters auf den Masterfolg

Zwecks Klärung der vorstehenden Frage wurden zunächst 51 junge Enten auf zwei Gruppen I^a und II^a verteilt unter Wiederholung des gleichen Versuches mit 43 Enten in zwei Gruppen I^b und II^b.

Für die Gruppen I^a und I^b wurde das Mastfutter zusammengesetzt aus: 15 Teilen Mischfutter, 10 Teilen Kartoffelflocken, und 10 Teilen grüne Luzerne. Das Mischfutter wies folgende Bestandteile auf: 20 Prozent Gerstenschrot, 20 Prozent Maisschrot, 20 Prozent Weizenkleie, 15 Prozent Dorschmehl, 15 Prozent Fleischmehl, 7 Prozent Zuckerschnitzel, 3 Prozent kohlensaurer Kalk + Holzkohle.

An die Gruppen II^a und II^b wurde in den ersten vier Mastwochen das Futter in gleicher Zusammensetzung verabreicht. Mit Beginn der 5. Mastwoche erfolgte zwecks Erweiterung des Nährstoffverhältnisses eine Aenderung der Mastfutterzusammensetzung auf etwa: 8 Teile Mischfutter, 17 Teile Kartoffelflocken, und 10 Teile grüne Luzerne.

Futterverzehr und Nährstoffaufnahme stellten sich in den einzelnen Gruppen auf ein Durchschnittstier berechnet wie folgt:

Tabelle 2

Gruppe	Anzahl d. Tiere	Verzehr eines Durchschnittstieres in kg an: Mischfutter	Kartoffel-flocken	grüne Luzerne	verdaul. Reineiweiss	Gesamtnähr-stoff	Eiweiss: Gesamtnähr-stoff
I^a	26	4.128	2.754	2.754	1.103	4.964	1:4,5
I^b	22	4.294	2.862	2.862	1.154	5.222	1:4,5
i. Durchschn.	48	4.211	2.808	2.808	1.129	5.093	1:4,5
II^a	25	2.118	1.411	1.411	0.558	2.511	1:4,5 1.–4. Woche
		1.543	3.279	1.929	0.565	3.712	1:6,6 ab 5. Woche
II^b	21	1.948	1.299	1.299	0.523	2.370	1:4,5 1.–4. Woche
		1.435	3.351	1.912	0.543	3.695	1:6,8 ab 5. Woche
i. Durchschn.	46	3.522	4.670	3.276	1.095	6.144	1:5,6

Die Uebersicht lässt erkennen, dass im Gesamtfutter der Gruppen I^a und I^b ein Nährstoffverhältnis von im Mittel 1:4,5 eingehalten wurde, ebenfalls in den ersten 4 Mastwochen der Gruppen II^a und II^b. Die Erweiterung des Nährstoffverhältnisses bei den beiden letzten Gruppen erfolgte bis auf 1:6,6 bezw. 1:6,8.

Die zur Erzielung eines Endgewichtes von 2000 g erforderlich gewesene Mastdauer mit entsprechender Gewichtszunahme sowie die Futterverwertung sind für die verschiedenen Abteilungen in der folgenden Tabelle 3 zusammengefasst:

Tabelle 3

Gruppe	Anzahl d. Tiere	Mastdauer Tage	Durchschnittl. Zunahme g	Je 100 kg Gewichtszunahme waren erforderlich in kg: Mischfutter	Kartoffel-flocken	grüne Luzerne	verdaul. Reineiweiss	Gesamt-nährstoff
I^a	26	47	1851	223	149	149	60	268
I^b	22	43	1825	235	157	157	63	286
i. Durchschn.	48	45	1838	229	153	153	62	277
II^a	25	52	1850	198	254	181	61	336
II^b	21	51	1833	185	254	175	58	331
i. Durchschn.	46	51	1842	192	254	178	60	334

Das Ergebnis des Versuches ist nach dieser Darstellung wie folgt zusammenzufassen. Die Verminderung des Eiweissgehaltes der Gesamtration junger Mastenten von der 5. Mastwoche ab hatte bis zur Erzielung eines Endgewichtes von 2,0 kg eine Verlängerung der Mastdauer um 13 Prozent, von 45 Tagen auf 51 Tage, zur Folge. Der Verbrauch an Gesamtnährstoff je Einheit Gewichtszuwachs erhöhte sich durch die gleiche Massnahme im Durchschnitt um 21 Prozent. Im Futteraufwand je 100 kg Gewichtszunahme standen im Durchschnitt einer Einsparung von 37 kg Mischfutter in den Gruppen II ein Mehraufwand von 101 kg Kartoffelflocken und 25 kg grüner Luzerne gegenüber. Damit wurde die Wirtschaftlichkeit der Mästung bei geringerer Eiweissgabe in Frage gestellt. Es erscheint hiernach geboten, das Verhältnis von Eiweiss zu Gesamtnährstoff in der Futterration bei der Mast junger Enten bis zur Mastbeendigung verhältnismässig eng, auf etwa 1:4,5, zu gestalten.

B. UNTERSUCHUNGEN ÜBER DIE EIGNUNG EINGESÄUERTER GEDÄMPFTER KARTOFFELN IM VERGLEICH ZU KARTOFFELFLOCKEN ALS MASTFUTTER FÜR JUNGENTEN

In 4 Versuchsgruppen mit 109 zu Versuchsbeginn 10 Tage alten Pekingenten wurde die vorbenannte Frage einer Prüfung unterzogen. In den Vergleichsreihen AI und BI wurde dabei ein relativ weites Nährstoffverhältnis von 1:6,5 bezw. 1:5,8 gewählt, während in den Reihen A II und BII der Eiweissanteil auf 1:4,7–4,5 erhöht wurde.

Das Mischfutter setzte sich aus folgenden Bestandteilen zusammen: für die Gruppen AI und BI

	Prozent
Weizenkleie	20
Gerstenschrot	20
Zuckerschnitzel	30
Süsslupinenschrot	18
Fischmehl	10
Kalksteinmehl	2

für die Gruppen A II und B II

	Prozent
Gerstenschrot	20
Maisschrot	20
Weizenkleie	20
Dorschmehl	15
Fleischmehl	15
Zuckerschnitzelschrot	7
kohlensaur. Kalk + Holzkohle	3

Der Futterverzehr und die Nährstoffaufnahme stellten sich in den verschiedenen Versuchsreihen, auf ein Durchschnittstier berechnet, wie folgt:

TABELLE 4

Gruppe	Anzahl d. Tiere	Verzehr eines Durchschnittstieres in kg an:						Eiweiss: Gesamtnährstoff
		Mischfutter	Kartoffelflocken	eingesäuerte Kartoffeln	grüne Luzernce	verdaul. Reineiweiss	Gesamtnährstoff	
A I	30	4.412	3.213	.....	3.213	0.841	5.438	1:6,5
A II	26	4.128	2.754	.....	2.754	1.055	4.964	1:4,7
im Durchschn.	56	4.270	2.984	.....	2.984	0.948	5.201	1:5,5
B I	29	5.170	.....	11.089	2.805	0.935	5.428	1:5,8
B II	24	4.240	.....	11.110	2.826	1.050	4.773	1:4,5
im Durchschn.	53	4.705	.....	11.100	2.816	0.993	5.101	1:5,1

Erwartungsgemäss nahmen die Enten etwa die vierfache Menge an eingesäuerten Kartoffeln im Vergleich zu Kartoffelflocken auf. In gesundheitlicher Hinsicht waren Störungen nicht zu vermerken.

Die bis zur Erreichung des Endgewichtes von 1800 g in den I-Reihen und von 2000 g in den II-Reihen ermittelte gewichtsmässige Entwicklung sowie die Futterverwertung sind der folgenden Tabelle 5 zu entnehmen.

Die Zusammenstellung lässt zunächst als Folge der grundsätzlich geringeren Eiweisszufuhr eine wesentlich geringere Gewichtszunahme bei A I und B I erkennen. Dementsprechend stellte sich die Futterverwertung bedeutend ungünstiger. In den Abteilungen A II und B II konnte dagegen in einer normalen Mastzeit von etwa 50 Tagen das Endgewicht von 2,0 kg bei guter Futterverwertung erreicht werden.

Der Vergleich der A-Gruppen mit Kartoffelflocken zu den B-Gruppen mit eingesäuerten

TABELLE 5

Gruppe	Anzahl d. Tiere	Anf.-Gewicht, g	Endgewicht, g	Zunahme, g	Mastdauer Tage	Je 100 kg. Gewichtszunahme waren erforderlich in kg:					
						Mischfutter	Kartoff flocken	eingesäuerte Kartoffeln	grüne Luzerne	verdaul. Reineweiss	Gesamtnährstoff
A I	30	136	1800	1664	66	265	193	..	193	51	327
A II	26	149	2000	1851	47	223	149	...	149	57	268
im Durchschnitt	56	143	1900	1758	57	244	171	.. .	171	54	298
B I	29	162	1800	1638	76	316	...	677	171	57	331
B II	24	148	2000	1852	51	229	....	600	152	57	258
im Durchschnitt	53	155	1900	1745	64	273	.	639	162	57	295

gedämpften Kartoffeln im Mastfutter liess sowohl in Bezug auf die Mastdauer als auch auf die Futterverwertung wesentliche Unterschiede in der Futterwirkung der beiden Formen der Kartoffel nicht erkennen.

Eine im Anschluss an den Fütterungsversuch der Gruppen A II und B II durchgeführte Beurteilung der Qualität der geschlachteten Enten ergab sowohl beim äusseren Befund wie bei der geschmacklichen Prüfung nach gleichmässigen Braten für beide verschiedenartig ernährten Gruppen eine übereinstimmend gute Bewertung.

Das Ergebnis der Untersuchung ist dahin zusammenzufassen, dass eingesäuerte gedämpfte Kartoffeln mit dem gleichen Erfolg wie Kartoffelflocken als Mastfutter für junge Enten von Mastbeginn an Verwendung finden können.

ZUSAMMENFASSUNG

An 94 auf vier Versuchsreihen verteilte Enten wurden Untersuchungen darüber angestellt, ob eine Einsparung von Eiweissfutter im Verlaufe einer intensiven Mast vom 10. Lebenstag bis zum Gewicht von 2,0 kg möglich und zweckmässig sei. Die Versuche führten zu dem eindeutigen Ergebnis, dass das Verhältnis von Eiweiss zu Gesamtnährstoff in der Futterration bei der Mast junger Enten bis zur Mastbeendigung auf 1:4,5 zu halten ist.

In vier weiteren Versuchsreihen mit insgesamt 109 Jungenten, die bis auf 1800 g und auf 2000 g gemästet wurden, konnte der Nachweis geführt werden, dass eingesäuerte gedämpfte Kartoffeln mit dem gleichen Erfolg wie Kartoffelflocken als Mastfutter für junge Enten von Mastbeginn an Verwendung finden können.

SUMMARY

With 94 ducklings divided into four test groups, investigations were undertaken to determine whether a saving of protein is possible and advisable during an intensive fattening process from the tenth day until the birds reach a final weight of 2 kg. The experiment showed definitely that during the fattening of ducklings the ratio of protein to total nutritive substance in the diet must be kept at 1:4.5 until the termination of the fattening process.

In four additional groups involving 109 ducklings fattened until they reached a final weight of 1,800 grams for two groups and 2,000 grams for two groups, soured steamed potatoes produced the same results as potato flakes as a fattening feed when fed from the beginning of the fattening period.